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Cunninghamia

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Allan Cunningham, botanist and explorer (1791–1839)

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Cover: Large River Red Gums, *Eucalyptus camaldulensis* , interspersed with small areas of wetland on the extensively cleared and grazed upper Murray River floodplain, east of Albury. Alluvial and floodplain vegetation have been severely altered in the 80% cleared NSW South-western Slopes Bioregion but diverse vegetation types survive in good condition in steep hilly terrain. Much of the country between the remnant hills is dominated by exotic pasture and isolated paddock trees with implications for long-term native species management. Photo Jaime Plaza

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Scientific Editor
Doug Benson
Royal Botanic Gardens,
Mrs Macquaries Road, Sydney, Australia 2000.
Email: doug.benson@rbgsyd.nsw.gov.au

Scientific Editorial Committee
Brett Summerell, John Benson, Bob Makinson,
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Typesetting and Production
Julia Sideris
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Is 500m^2 an effective plot size to sample floristic diversity for Queensland's vegetation?

V.J. Neldner and D. W. Butler

Queensland Herbarium, Environmental Protection Agency, Mt Coot-tha Botanic Gardens, Mt Coot-tha Road, Toowong, QLD 4066, AUSTRALIA. Email: john.neldner@epa.qld.gov.au

Abstract: Species area curves from 37 sites spanning the diversity of native vegetation in Queensland were examined. For the majority of sites investigated a 500 m^2 plot captured about 80–90% of the vascular plant species present at the time of sampling. Floristic data collected for grassland, heathland, acacia shrublands and most eucalypt woodlands using a 500 m^2 plot is appropriate for floristic analysis and adequately represent the vascular plants present at the site at the time. Using a larger plot would only slightly increase the species capture at a site but it would generally be more efficient to increase the number of sites sampled to more adequately capture the diversity across the extent of the vegetation type. However for many Queensland rainforest communities, a much larger sample size is required to capture the full species richness of a site.

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Introduction

Plot-based data on vegetation composition has a multitude of uses and is rightly considered primary descriptive data from vegetation surveys. Whether users are writing map-unit descriptions or undertaking more complex quantitative analyses or modelling, they need to have confidence that the plot size and methodology used was appropriate to capture the majority of species present at a site. This paper examines species area curves from a structurally and floristically diverse array of vegetation from across Queensland to assess the effectiveness of 500 m^2 plots as samples of local floristic richness.

Queensland's diverse vegetation

The state of Queensland has a diverse array of vegetation ranging from the moist mega-diverse rainforests of the Wet Tropics, to the arid hummock grasslands of the Simpson Desert in the south west. Currently 1383 regional ecosystems are recognised at the regional (1:100 000) scale for the state (Accad *et al.* 2006). On a state wide basis, the majority of the pre-clearing vegetation was dominated by eucalypt woodlands and open-forests (44.4%), with extensive areas formerly covered with *Acacia* dominated woodlands and shrublands (22.8%). There are also large areas of *Astrebla* and other genera dominated tussock grasslands (20.1%) and *Triodia* dominated hummock grasslands (3.1%). Rainforests (2.2%), wetlands (5.4%), mangroves (1.1%) and heathlands (0.9%) cover much less extensive areas (derived from Appendix 3 in Wilson *et al.* 2002).

The Queensland Herbarium has had a long term program of survey and mapping vegetation of the state (Neldner 1993) and in recent years this mapping has been utilised for the *Vegetation Management Act 1999* (*VMA 1999*), which regulates tree clearing. The collection of detailed structural and floristic data is a core component of vegetation survey and mapping. The Herbarium program is structured around the mapping of vegetation communities at the 1:100 000 scale, and the site sampling aims to typify vegetation communities and regional ecosystems which are recognised and classified at the 1:100 000 scale. The Herbarium's botanists use standardised data collection procedures to maximise comparability of data between different collectors and across the wide range of vegetation types in the state. Apart from ground truthing the mapping, the vegetation data collected are providing a comprehensive floristic and structural inventory of Queensland's vegetation. It has hence been important to choose a plot size appropriate for sampling local-scale plant species richness across the wide range of vegetation types in Queensland.

Aim of this study

The aim of this study was to assess the effectiveness of 500 m^2 plots used in the Herbarium's survey and mapping methodology (Neldner *et al.* 2005) by examining the effect of sample area on species richness across a diverse range of the types of vegetation found in Queensland. The results provide information on the relative value (in terms of percentage floristic diversity capture) and limits to use of data collected at different size plots in different vegetation.

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Table 1. Details of the sites included in this study and some important characteristics of the pattern of vascular plant species accumulation therein.

Site	Vegetation	Location	Total sampled area (m^2)	Total species at site	% of total recorded species at 500 m^2	Minimal area (95% species)	Gradient @ 500 m^2	#
1	*Astrebla lappacea* tussock grassland	north of Longreach 23°13'S 144°21'E	500	34	100	65	0.0	A
2	*Astrebla lappacea* tussock grassland	north of Longreach 23°45'S 144°29'E	1000	35	100	65	0.0	A
3	*Imperata cylindrica* closed-tussock grassland	Lockhart River 12°49'S 143°18'E	500	13	100	15	0.0	B
4	*Neofabricia myrtifolia, Allocasuarina littoralis* open-heath	Heathlands 11°43'S 142°31'E	500	20	100	23	0.0	B
5	*Neofabricia myrtifolia, Thyrptomene oligandra* open-heath	Heathlands 11°44'S 142°32'E	500	18	100	25	0.0	B
6	Sandplain dwarf heath	Cape Flattery 14°59'S 145°18'E	1000	23	96	100	0.0	C
7	Quaternary dunefield heath	Cape Flattery 14°59'S 145°18'E	1000	30	97	100	0.0	C
8	Quaternary dunefield wet heath	Cape Flattery 15°01'S 145°18'E	1000	24	100	100	0.001	C
9	Frontal dune exposed heath	Cape Flattery 15°01'S 145°18'E	1000	20	95	100	0.001	C
10	*Banksia aemula* woodland with dense low heath understorey	North Stradbroke Island 27°38'S 153°26'E	2050	48	91	872	0.005	D
11	*Acacia cambagei tall* shrubland	Hughenden 21°12'S 144°28'E	980	26	96	340	0.002	E
12	*Acacia harpophylla* tall shrubland	Eringibba National Park 27°18'S 149°41'E	750	37	99	490	0.002	F
13	*Acacia aneura* tall shrubland	Culgoa Floodplains National Park 28°54'S 146°58'E	650	37	97	210	0.004	G
14	*Melaleuca viridiflora* low open-woodland	Lakefield 15°16'S 144°38'E	1200	39	94	590	0.004	H
15	*Eucalyptus chlorophylla* woodland	Lakefield 15°22'S 144°26'E	1450	47	80	1000	0.017	H
16	*Eucalyptus tetrodonta, Erythrophleum chlorostachyus* woodland	near Laura 15°27'S 144°26'E	2900	73	79	1600	0.011	H
17	*Eucalyptus tetrodonta, Corymbia setosa* woodland	Strathgordon 14°52'S 142°30'E	660	52	99	250	0.007	B
18	*Eucalyptus platyphylla, E. leptophleba* open-woodland	near Mareeba 16°51'S 145°23'E	1300	43	85	1000	0.008	B
19	*Eucalyptus persistens* low open-woodland	White Mountains 20°27'S 144°50'E	760	45	94	530	0.011	I
20	*Eucalyptus quadricostata, Corymbia brachycarpa* woodland	White Mountains 20°27'S 144°50'E	1150	45	90	760	0.001	I
21	*Eucalyptus similis* woodland	White Mountains 20°34'S 144°15'E	500	54	100	280	<0.01	J
22	*Eucalyptus coolabah* open-woodland	Hebel 28°52'S 147°40'E	730	35	96	450	0.008	G
23	*Callitris glaucophylla Eucalyptus caleyi, E. dealbata,* woodland	near Texas 28°32'S 151°05'E	2500	30	87	1750	0.002	K
24	*Callitris glaucophylla* woodland with emergent *Angophora leiocarpa*	near Texas 28°59'S 151°12'E	2500	40	78	2000	0.01	K
25	*Eucalyptus albens, E. dealbata* woodland	near Texas 28°56'S 151°21'E	2500	32	84	1300	0.008	K

Site	Vegetation	Location	Total sampled area (m^2)	Total species at site	% of total recorded species at 500 m^2	Minimal area (95% species)	Gradient @ 500 m^2	#
26	*Eucalyptus caleyi, E. dealbata* woodland	near Texas 28°38'S 151°20'E	2500	35	86	900	0.01	K
27	*Eucalyptus dealbata, Callitris glaucophylla* woodland	near Texas 28°34'S 151°23'E	2500	29	69	970	0.01	K
28	*Eucalyptus dealbata, E.caleyi, Callitris endlicheri* woodland	near Texas 28°35'S 151°09'E	2500	30	86	1370	0.01	K
29	*Eucalyptus crebra, E. moluccana, Angophora leiocarpa* open-forest	near Texas 28°41'S 151°10'E	2500	60	77	1860	0.03	L
30	*Eucalyptus crebra, Allocasuarina luehmannii* woodland	near Texas 28°35'S 151°03'E	2500	17	82	850	0.01	K
31	*Eucalyptus fibrosa* woodland	near Texas 28°39'S 151°08'E	2500	58	81	2000	0.01	L
32	*Eucalyptus melanophloia, Callitris glaucophylla, E. dealbata* woodland	near Texas 28°59'S 151°09'E	2500	34	82	1700	0.02	K
33	*Eucalyptus pillagensis, E. molucanna* woodland	near Texas 28°37'S 151°19'E	2500	26	69	880	0.02	K
34	*Eucalyptus terrica, E.crebra, Callitris endlicheri* woodland	near Texas 28°30'S 151°14'E	2500	26	81	950	0.01	K
35	Low microphyll vine forest	Western Bunya Mountains 26°50'S 151°32'E	10000	59*	66	7000	0.01	M
36	Araucaurian notophyll vine forest	Eastern Bunya Mountains 26°52'S 151°36'E	10000	60*	57	6000	0.02	M
37	Regrowth complex notophyll vine forest	Mt Glorious 27°20'S 152°43'E	800	115*	86	695	0.07	N

# Botanists: A = H. Cartan; B = V.J.Neldner; C = N.Cuff; D = K.M. Stephens; E = H. Cartan & C.Kahler; F = B.A.Wilson; G = M.Schmeider; H = V.J.Neldner & D. Milne; I = V.J.Neldner & R.J.Cumming; J = E.J.Thompson & R.J.Cumming; K = K.M.Sparshott & A.R.Bean; L = K.M.Sparshott & E.J.Thompson; M = D.W.Butler; N = D.W.Butler & A.J.Franks.

* = only trees and shrubs sampled at these sites

Methods

Plots from 37 sites across Queensland were included in this study (Fig.1, Table 1). The sites were from a range of native vegetation types (all classified as remnant under the *VMA 1999*) and were sampled over a period of years (1988–2000) by a number of Queensland Herbarium botanists. The plots were all located in contiguous areas of the same vegetation type and were generally sampled at a time when the maximum plant species diversity would be present, eg. sampling eucalypt woodlands in the tropical savannas in the late wet season yields more than 80% of the overall floristic diversity recorded in repeated samples (Neldner *et al.* 2005). All vascular plant taxa were recorded at most sites, the exceptions were the three sites from rainforests (35–37) in which only tree and shrub species were recorded. In rainforests the majority of the vascular plant diversity is captured by the woody plants as ground-dwelling grasses and forbs are relatively uncommon. Plant nomenclature follows Bostock and Holland (2007).

For 18 sites, the data were collected by sampling contingous quadrats arrayed on a continuous grid. The plot size generally started as a 0.5 m^2 quadrat, with contiguous 1.0 m^2 quadrats added out along a 50 metre transect line and any additional species recorded with each new quadrat. At the completion

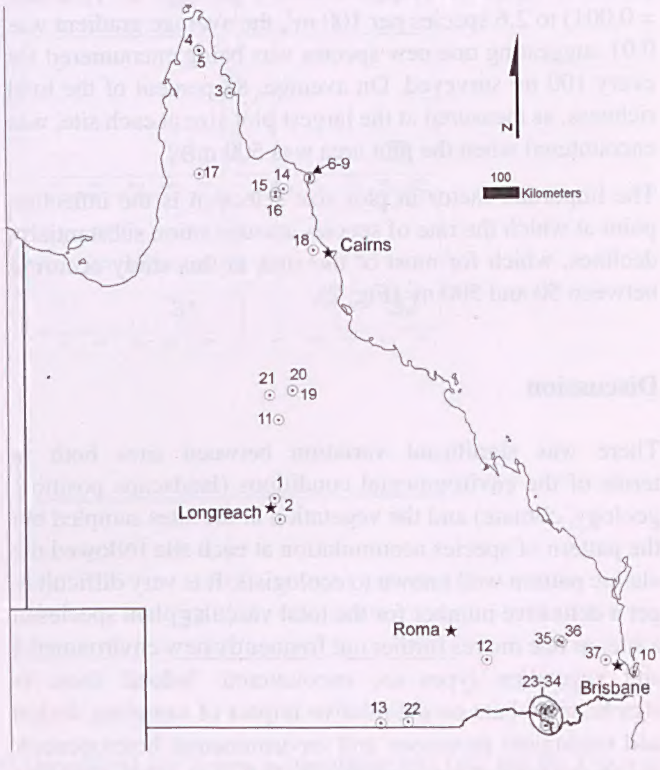

Fig. 1. Map of Queensland showing the locations of the 37 sites included in this study.

of the first 50 m, the transect line was moved up a metre and the quadrats sampled in the reverse direction. The sampling was terminated when the rate of recording new species was very low, such that the botanist assumed the total richness was captured. Graphs of the number of species encountered at the accumulated overall sample area for each site were generated. For the remaining 19 sites, data were collected in nested quadrats with incrementally pre-determined larger plot sizes added. The total accumulated species number for each plot size were then recorded. The rate at which new species were still being encountered at and beyond a plot size of 500 m^2 was estimated using a linear model based upon data points close to and beyond this threshold.

Results

Table 1 presents basic plot statistics as well as estimates of the percentage of the total species richness recorded at the site which was encountered in the first 500 m^2, and the rate at which previously unrecorded species were being encountered at 500 m^2 . The largest plot size at the sites ranged from 80 m^2 to 10 000 m^2 and the number of species encountered ranged from 13 to 115. Species area curves for each plot are presented in Figure 2. Only a few sites reached a plateau of no additional species being found with increasing area; three tropical heathlands (sites 4, 5 and 8) and three grasslands (sites 1–3). Most of the curves had passed the inflection point and commenced to plateau by the time plot area passed 500 m^2. Estimates of the rate of species accumulation at 500 m^2 (Table 1) varied between one species per 1000 m^2 (gradient = 0.001) to 2.6 species per 100 m^2, the average gradient was 0.01 suggesting one new species was being encountered for every 100 m^2 surveyed. On average, 88 percent of the total richness, as measured at the largest plot size at each site, was encountered when the plot area was 500 m^2.

The important factor in plot size selection is the inflection point at which the rate of species accumulation substantially declines, which for most of the sites in this study occurred between 50 and 500 m^2 (Fig. 2).

Discussion

There was significant variation between sites both in terms of the environmental conditions (landscape position, geology, climate) and the vegetation at the sites sampled but the pattern of species accumulation at each site followed the classic pattern well known to ecologists. It is very difficult to get a definitive number for the total vascular plant species at a site, as one moves further out frequently new environments and vegetation types are encountered. Indeed, there is significant debate on the relative impact of sampling design and ecological processes and environmental heterogeneity has on the type of curve produced (Hill *et al.* 1994, Scheiner 2003, 2004, Gray *et al.* 2004a, b).

In this investigation we are examining the local-scale richness within a vegetation community at a site. A 500 m^2 plot appears adequate for sampling the floristic richness at a given location (alpha diversity) for most types of vegetation in Queensland, recording about 88% of species present in the vicinity. Rainforests are an exception, this study included two rainforest sites in which the rate of new species being encountered did not decline until about 2000 m^2 had been sampled (sites 35 and 36). This may simply be explained by the high richness of large life-forms each requiring more space in rainforests.

Dense communities with relatively small predominant life-forms, such as heathlands and grasslands, showed little species accumulation after just 20 – 30 m^2. It could be argued that smaller plots, in the order of 100m^2, can be used in some less diverse vegetation types such as grasslands and heathlands of northern Queensland. This may be the case if only one vegetation type or structural formation were to be investigated, eg. a study of Queensland grasslands. However the advantages of a standard plot size in a Queensland wide methodology is that it allows comparisons of species richness across vegetation types. Operationally there are advantages in using a standard methodology by different botanists in different vegetation types across the State. Any cost savings by reducing the sample area of sites in simpler communities would be very limited, as the communities are easy to move through and few additional species will be encountered.

For eucalypt woodlands and open-forests, 500m^2 is often close to the break of slope in the species area curve and typically captures about 85% of species. Our data suggest that plot sizes of 1000m^2 or larger may be needed to capture over 90% of species in such communities.

These findings accord with other studies of species area relationships for vascular plants. Mueller-Dombois & Ellenberg (1974) estimated appropriate plot sizes of 200–500 m^2 for temperate zone forests, 50–100 m^2 for grassland and 10–25 m^2 for dwarf–shrub heath, while Kent and Coker (1994) recommend plot sizes of 400–2500 m^2 for woodlands, 100 m^2 for scrub/ shrub woodlands and 4–26 m^2 for heaths and grasslands. Ashton's data for tropical rainforest of Borneo (Ashton 1965 redrafted in Mueller-Dombois & Ellenberg 1974) included six species area curves only one of which showed a distinct levelling off within two hectares, suggesting a minimal area for these communities around five hectares.

The overall statistics on vascular plant richness recorded in this study are comparable with other Australian surveys, for example the total species recorded in grassy Eucalypt woodlands in northern Queensland range from 43 to 73 species from plots ranging from 450–2900 m^2 (sites 17–22), with 37–62 species being recorded from 1000 m^2 by Rice and Westoby (1983) and 42–61 species from 1600 m^2 plots by Taylor and Dunlop (1985) in similar vegetation in the Northern Territory. In 1000 m^2 plots in temperate New South Wales, 32–36 species were recorded in Eucalypt forests by Rice and Westoby (1983) and a

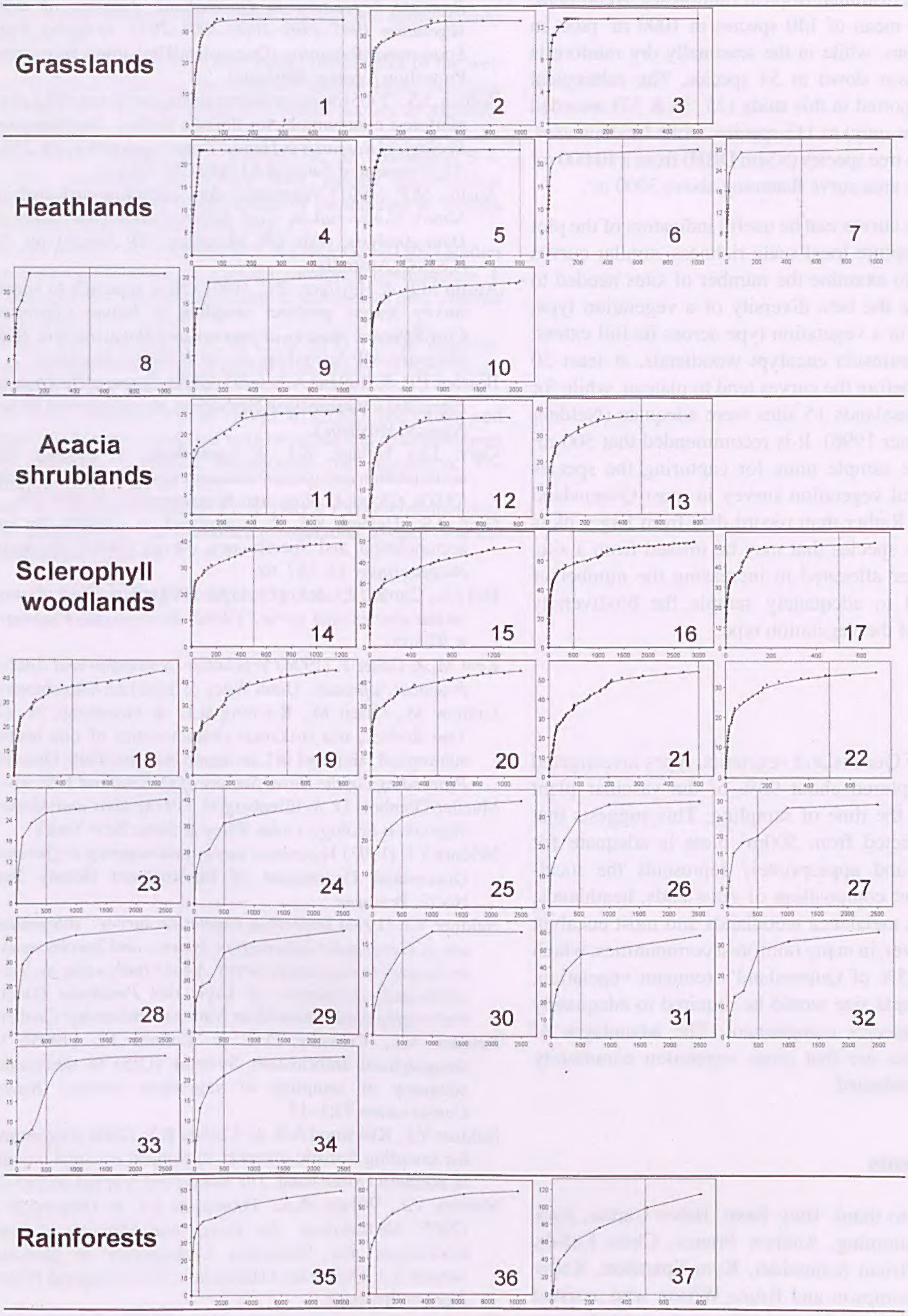

Fig. 2. Species area curves for vascular plant species at 37 sites across Queensland, the X-axis is cumulative area (m^2) and the Y-axis is cumulative number of plant species recorded. The numbers refer to site numbers in table 1 and figure 1. The 500 m^2 plot is indicated by the dotted vertical line. Lines were fitted using various smoothing algorithms in Splus 7.0.

mean number of 53 species in mallee by Whittaker *et al.* (1979) which compares favourably with the 30–59 species recorded in sites 23–34. In Australian tropical rainforests, Webb *et al.* (1967) recorded a mean of 140 species in 1000 m^2 plots in the wettest situations, while in the seasonally dry rainforests species diversity was down to 54 species. The subtropical rainforests sites reported in this study (35, 36 & 37) recorded 59 (trees and shrubs only) to 115 species, while Laidlaw *et al.* (2000) recorded 74 tree species (>5cm DBH) from a 10 000 m^2 plot, with a species area curve flattening above 3000 m^2.

While species area curves can be useful indicators of the plot size required to capture local-scale richness, similar curves are also required to examine the number of sites needed to adequately capture the beta diversity of a vegetation type, eg. total diversity in a vegetation type across its full extent. For Cape York Peninsula eucalypt woodlands, at least 30 sites are required before the curves tend to plateau, while for heathlands and grasslands 15 sites were adequate (Neldner *et al.* 1995; Neldner 1996). It is recommended that 500 m^2 plots are adequate sample units for capturing the species at a site for general vegetation survey in most Queensland vegetation types. Rather than record data from larger plots to capture the few species that may be missed from a site, resources are better allocated to increasing the number of locations sampled to adequately sample the biodiversity across the extent of the vegetation type.

Conclusions

For the majority of Queensland vegetation types investigated a 500 m^2 plot captured about 90% of the vascular plant species present at the time of sampling. This suggests that floristic data collected from 500m^2 plots is adequate for floristic analysis and appropriately represents the local-scale vascular plant composition of grasslands, heathlands, acacia shrublands, melaleuca woodlands and most eucalypt woodlands. However, in many rainforest communities, which cover less than 1.5% of Queensland's remnant vegetation, a much larger sample size would be required to adequately capture the full species complement. The advantages of a standard plot size are that cross vegetation community analyses can be conducted.

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Lose the plot: cost-effective survey of the Peak Range, central Queensland.

Don W. Butler[a] *and Rod J. Fensham*

Queensland Herbarium, Environmental Protection Agency, Mt Coot-tha Botanic Gardens, Mt Coot-tha Road, Toowong, QLD, 4066 AUSTRALIA. [a]Corresponding author, email: don.butler@epa.qld.gov.au

Abstract: The Peak Range (22° 28' S; 147° 53' E) is an archipelago of rocky peaks set in grassy basalt rolling-plains, east of Clermont in central Queensland. This report describes the flora and vegetation based on surveys of 26 peaks. The survey recorded all plant species encountered on traverses of distinct habitat zones, which included the 'matrix' adjacent to each peak. The method involved effort comparable to a general flora survey but provided sufficient information to also describe floristic association among peaks, broad habitat types, and contrast vegetation on the peaks with the surrounding landscape matrix.

The flora of the Peak Range includes at least 507 native vascular plant species, representing 84 plant families. Exotic species are relatively few, with 36 species recorded, but can be quite prominent in some situations. The most abundant exotic plants are the grass *Melinis repens* and the forb *Bidens bipinnata*. Plant distribution patterns among peaks suggest three primary groups related to position within the range and geology. The Peak Range makes a substantial contribution to the botanical diversity of its region and harbours several endemic plants among a flora clearly distinct from that of the surrounding terrain. The distinctiveness of the range's flora is due to two habitat components: dry rainforest patches reliant upon fire protection afforded by cliffs and scree, and; rocky summits and hillsides supporting xeric shrublands. Plants endemic to the Peak Range are mainly associated with the latter of these habitats.

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Introduction

Massive rocky outcrops frequently harbour an interesting and unusual flora (Porembski and Barthlott 2000). Australian rock outcrops are depauperate in specialised succulent life-forms that have diversified on outcrops in other regions (Hopper *et al.* 1997, Clarke 2002a), but diversification has occurred among scleromorphic shrubs and herbs (Hunter 2003). Limited soil development and low water-holding capacity makes rock outcrops relatively arid environs. Rocky outcrops can provide sharp environmental contrasts with the landscape around them, which makes them interesting models by which to understand factors that control vegetation composition.

Knowledge of the unusual flora of rock outcrops is based mainly on flora surveys and the specimens and subsequent taxonomic descriptions that are their main products. Such knowledge allows regional or broader-scale accounts of biogeographic pattern and endemism (eg. Batianoff *et al.* 1991, Hopper *et al.* 1997). However, more detailed phytosociological and ecological studies of rock outcrop vegetation have generally been based on plot-based surveys (eg. Kirkpatrick *et al.* 1988, Gibson *et al.* 1992, Hunter and Clarke 1998), which require far greater investment of time and resources than flora surveys but yield more detailed insights into patterns and processes. This study attempts to steer a course between these two sampling strategies, to glean some information on pattern and process more typical of plot-based surveys using a plot-free, traverse-survey technique comparable to flora survey in its demand on resources.

Primarily, we provide a descriptive study of the vegetation of an archipelago of prominent rocky peaks set in grassy rolling basalt-plains in semi-arid central Queensland, the Peak Range. Similarities and differences between vegetation of the peaks and surrounding plains are described, and floristic patterns are analysed among peaks and also for habitats within peaks. The ecological processes underlying these patterns are discussed.

Methods

Study area

The Peak Range forms a north-west orientated chain of peaks 66 km from the northern-most Mt Castor (22°28' S 147°53' E) to the southern-most The Woolbale (22°55' S, 148°17' E) (Figure 1). The nearby town of Clermont receives an annual average of 660 mm rainfall, concentrated in the summer

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months, and has annual mean maximum and minimum temperatures of 29.7°C and 15.0°C (Australian Bureau of Meteorology 2007).

The Peak Range and the surrounding fertile basalt plains are artefacts of volcanic activity from about 32 to 29 million years ago in the Tertiary period (Willmott 2006). The peaks include steep-sided plugs from volcanic vents, massive thrust domes produced by magma intrusions, and steep-sided basalt hills that are remnants of much-eroded Tertiary lava flows. Figure 2 provides photographs of some Peak Range landscapes.

The Peak Range includes two distinct clusters of plugs and domes of hard, light-coloured trachyte and rhyolite, one at each end of the range (Figure 1). The southern cluster includes the tallest peak in the range, Scotts Peak, which rises from its base at about 420 m ASL to an altitude of 854 m ASL. The middle section of the Peak Range consists of a series of steep-sided basalt hills, including the mesa-shaped Lords Table Mountain, capped by an erosion resistant layer of trachyandesite or trachyte, overlaying layers of basalt (Willmott 2006). Lords Table Mountain's slopes support the largest area of dry rainforest (semi-evergreen vine-thicket) in the Peak Range, and the 30 m cliffs that surround the mountain's top keep the summit plateau beyond the reach of domestic stock. The grassland vegetation on the plateau has been described (Fensham and Holman 1998) and is recognised as a unique regional ecosystem (11.8.10) within Queensland's state-wide land classification scheme (Sattler and Williams 1999).

Parts of the Peak Range are protected within the Peak Range National Park which has four disjointed sections that cover a total of 2500 ha; Wolfang Peak (172 ha), Gemini Mountains (787 ha), Lords Table (784 ha) and Eastern Peak (761 ha).

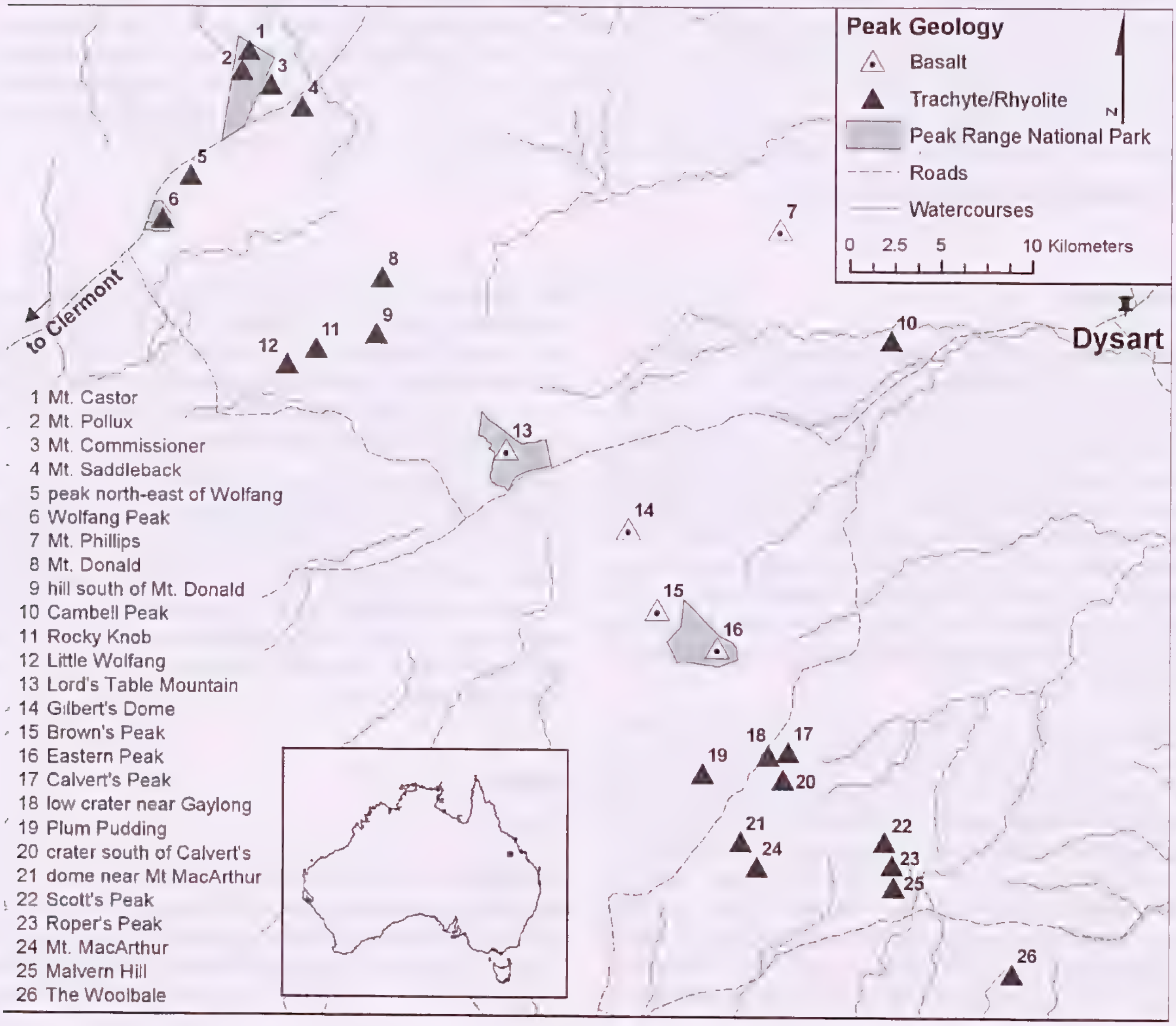

Fig. 1. A map showing the Peak Range National Park and the twenty-six features of the Peak Range included in this study. Symbols differentiate basalt hills from outcrops of trachyte or rhyolite.

Flora data and surveys

Vegetation surveys were undertaken in February and June 2006 and involved making full floristic lists for distinct habitat zones such as skeletal outcrop and soiled lower slopes. A list of species growing on the plain adjacent to each peak was also compiled. Voucher specimens are lodged at the Queensland Herbarium and nomenclature follows Bostock and Holland (2007).

Analysis

Analysis of plant distributions was undertaken at two scales: whole peaks (n = 26); and, individual habitats (n = 69). Flora data for the whole peak scale included 2006 survey data as well as records from the Queensland Herbarium's specimen database (HERBRECS), and previous survey's of Lords Table Mountain (Fensham 1995, Fensham & Holman 1998). A dissimilarity measure based on presence-absence data was calculated using Bray-Curtis Index. Classifications (UPGMA with Beta = -0.1) were run in PATN 3.0. The groups identified in the classification were further assessed in PRIMER 5.1 using ordination (NMDS) to visualise inter-relationships, SIMPER to assess the contributions of individual species to dissimilarity between groups of peaks or habitats, and ANOSIM to assess the robustness of the groups.

Average species richness and percentages of species in life-form classes were compared between habitat groups using Kruskal-Wallis tests with Wilcoxon rank-sum tests for subsequent pair-wise comparisons where overall differences were significant.

Nestedness in the distributions of species across peaks was assessed using 'The nestedness temperature calculator' of Atmar and Patterson (1995). In a strongly nested system the most hospitable habitat units (peaks in this case) harbour more species, especially uncommon species, whereas the least hospitable harbour a small subset of common species. The program ranks peaks from most to least hospitable and species from most stable (least likely to go extinct) to most tenuous in the system (Atmar and Patterson 1993). Stable species tend to be common or associated with hospitable peaks. The 'calculator' uses randomisation to estimate the probability of the degree of nestedness observed in a dataset occurring by chance.

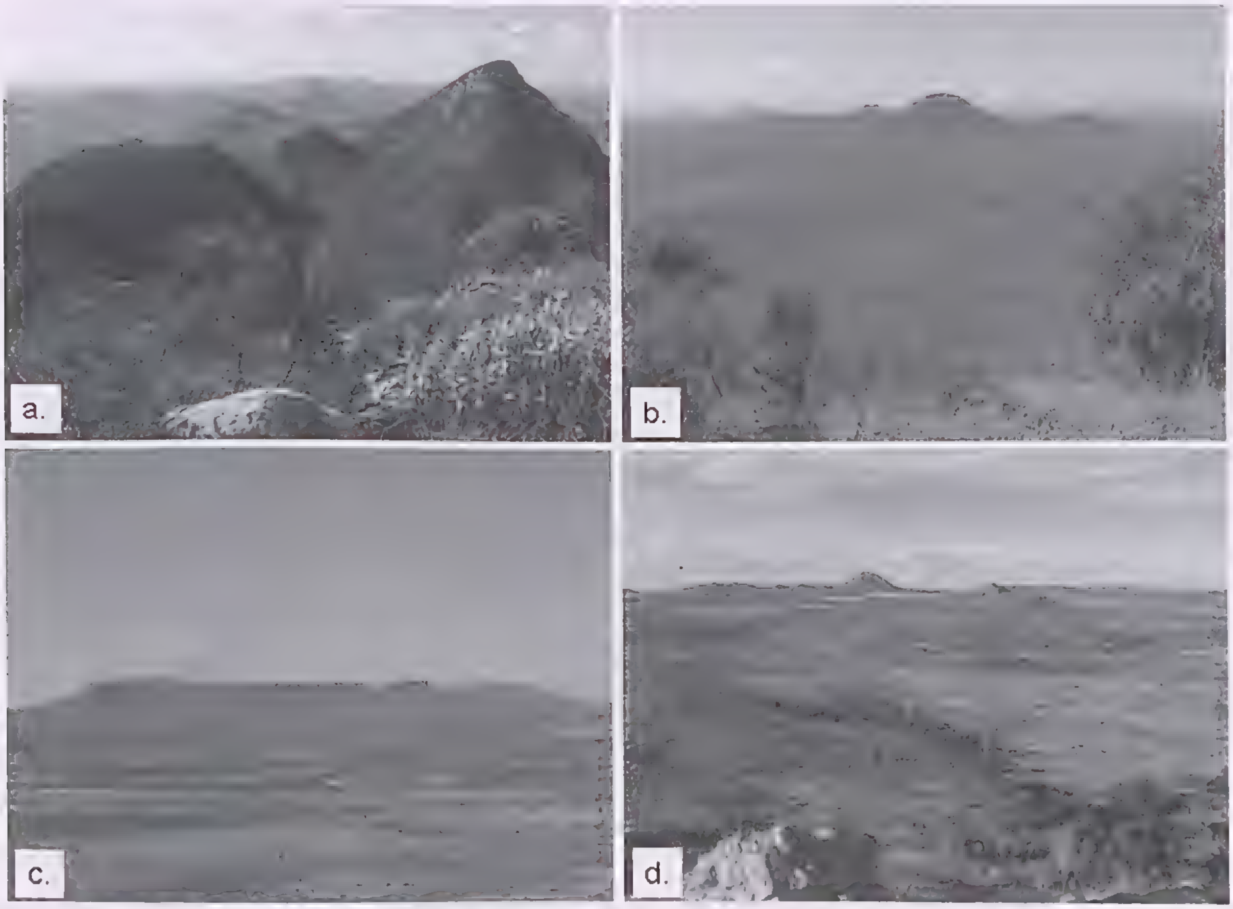

Fig. 2. Some Peak Range landscapes: **a.** southern section, looking north from Ropers Peak toward Scotts Peak, note the low profile thrust domes in the upper central section of the photograph; **b.** central section with steep-sided basalt hills, looking south from the top of Gilberts Dome to Browns Peak (centre top) and Eastern Peak (behind and left of Browns Peak); **c.** central section, Lords Table looking south from Little Wolfang; **d.** northern section of the range looking north-east from Little Wolfang past Rocky Knob (centre right) to Mt Donald (centre left).

Results

The flora of the Peak Range includes at least 507 native vascular plant species, representing 84 plant families. Exotic plants added a further 36 species and two additional families. A complete list is provided as an Appendix.

Table 1 provides details of plants endemic to the Peak Range as well as those listed as rare or threatened under Queensland's *Nature Conservation Act 1992* (NCA). They occur across the length of the range, and on both basalt and on trachyte/rhyolite peaks. The endemic *Acacia* species and *Plectranthus* species are all associated with very rocky habitats. Another endemic, *Trioncinia patens*, occurs on the lower slopes of three peaks.

Some plant populations on the Peak Range represent substantial range outliers. For example, *Cyperus cunninghamii* subsp. *cunninghamii* occurs atop Mt Castor but the nearest known population is over 800 km to the west near Cloncurry. *Prostanthera lithospermoides* occurs on Mt Donald but its nearest known population is 300 km to the south in the Carnarvon Ranges. Such outliers also tend to be associated with rocky habitats in the Peak Range.

Patterns among peaks

Analysis of plant distributions at the peak-scale, suggests a primary split based on geography rather than geology, between the peaks south from Calverts Peak and those further north (Figure 3, Groups A&B vs. C&D). The only exception was Mt Donald, which is in the northern part of the range but was placed in Group C among peaks from the south. Within the northern section the basalt hills (Group A) were differentiated from the trachyte/rhyolite peaks and domes (Group B). In the south, the major peaks (Group C) were differentiated from lower profile thrust domes which tend to support less variable vegetation (Group D), mainly very open woodlands of yellow-jackets (*Corymbia leichhardtii* and *Corymbia peltata*) with a sparse grassy understorey on shallow stony soil with patches of rock pavement.

Assessment of nestedness across the 26 peaks indicated a strongly non-random arrangement of species across peaks. However, there was also ample evidence for idiosyncratic species distributions, which indicate complex rather than strongly nested patterns. The rank of each peak from most to least hospitable is provided in Figure 3. The three most hospitable peaks were Lords Table Mountain, Mt Castor

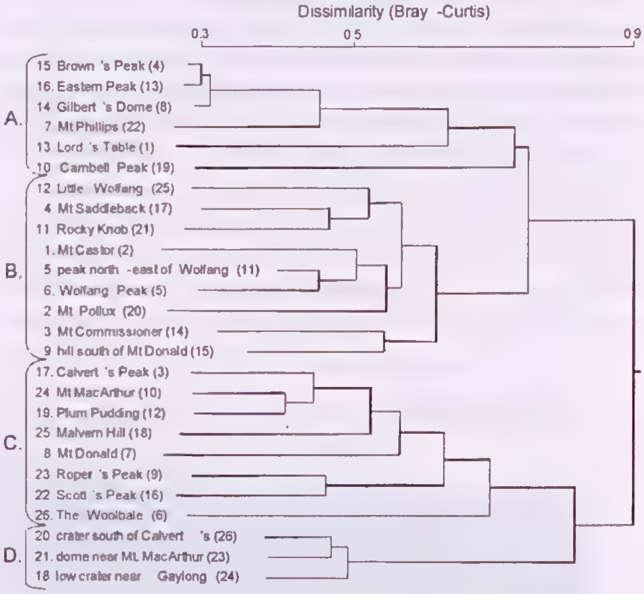

Fig. 3. A dendrogram showing relationships between 26 features of the Peak Range based on plant species presence and absence. Four main groups of peaks are identified by letters and brackets on the left of the diagram. The 'hospitability' rank for each feature, based on nestedness, is provided after its name in brackets. The classification method was flexible UPGMA (Beta = -0.10) on a Bray & Curtis dissimilarity matrix.

Table 1. Endemic and listed threatened plants of the Peak Range.

Species	NCA status	EPBC status	Endemicity	Peaks (key in fig. 1)
Acacia arbiana	Rare	-	endemic	4, 12, 17, 18, 19, 22, 23, 26
Acacia sp. (D.W. Butler 98)	-	-	endemic	1, 2
Acacia sp. (D.W. Butler+ 178)	-	-	probable endemic	8
Bertya pedicellata	Rare	-	not endemic	1, 4, 6, 8, 11, 17, 22, 23, 26
Cerbera dumicola	Rare		not endemic	26
Dichanthium queenslandicum	Vulnerable	Vulnerable	not endemic	matrix only
Persoonia amaliae	Rare	-	not endemic	23
Plectranthus actites	-	-	endemic	13
Plectranthus sp. (R.J. Fensham RJF5424)	-	-	probable endemic	26
Plectranthus sp. (D.W. Butler 179)	-	-	probable endemic	8
Trioncinia patens	-	-	endemic	1, 15, 16

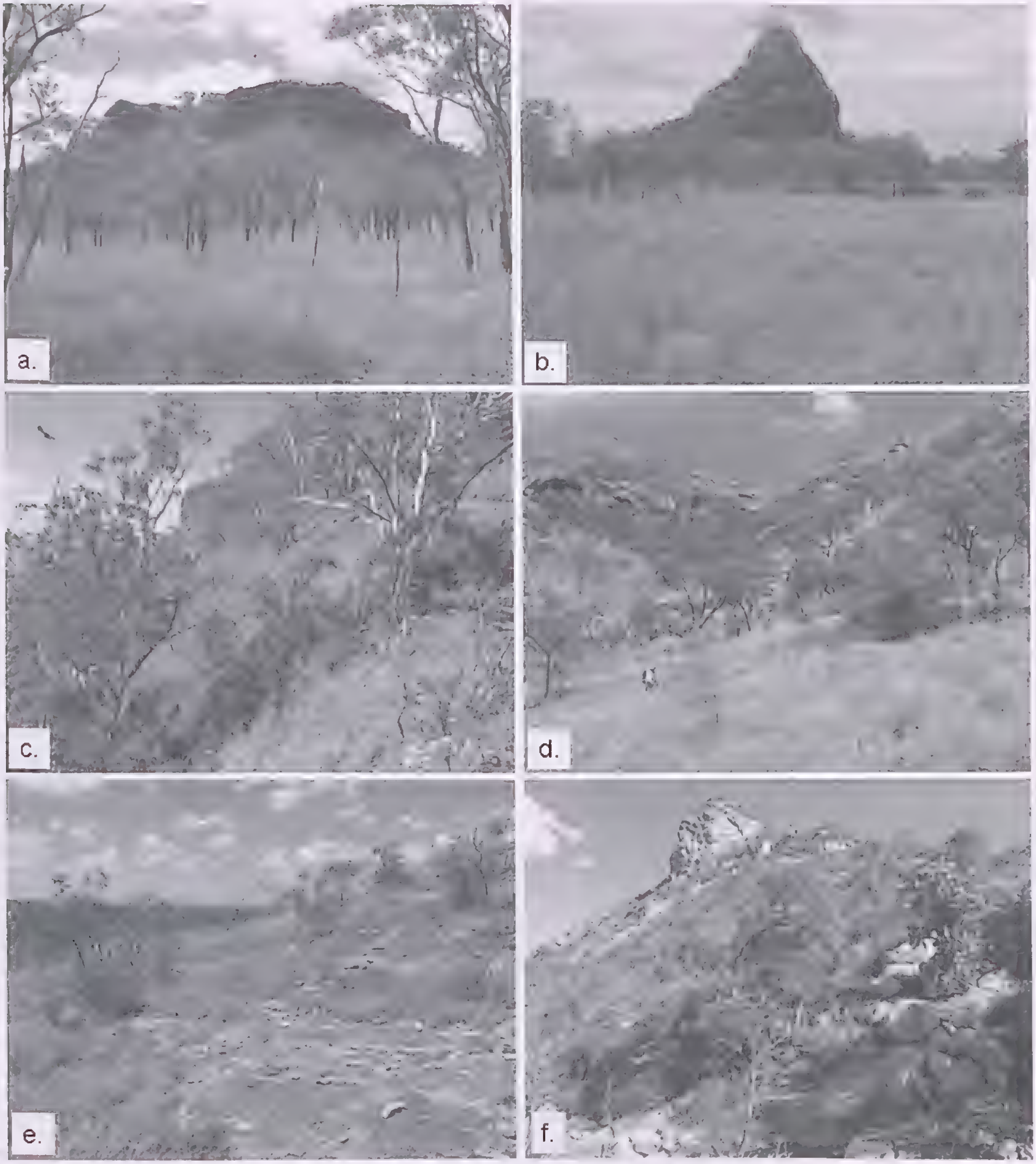

Fig. 4. Photographs of examples of three broad Habitats identified for the Peak Range. a. Habitat 1, grassy *Eucalyptus orgadophila, E. crebra* and *C. erythrophloia* woodland north of Gilberts Dome; b. Habitat 1, grassland and grassy *Eucalyptus orgadophila* woodland north of Wolfang Peak; c. Habitat 2, grassy *Eucalyptus orgadophila* woodland with patchy rainforest shrubs on the steep basaltic slopes of Browns Peak; d. Habitat 2, a mosaic of grassy *Corymbia trachyphloia* woodland, rainforest patches (eg. centre left), and rocky shrubland with spinifex on Mt Pollux; e. Habitat 3, rocky shrubland with low *Eucalyptus exserta* and *Acacia arbiana* on The Woolbale; f. Habitat 3, rocky shrubland atop Ropers Peak.

and Calverts Peak. Between them these three peaks support nearly 70% of the native plants recorded from the peaks.

Lords Table Mountain supports more than twice as many plant species as any other peak and has the greatest concentration of species restricted to one peak, most of which are associated with the extensive dry rainforest on its slopes. However, it also has an endemic plant (*Plectranthus actites*) and the ecosystem on its summit is considered unique in the region. Steep-sided basalt hills like Lords Table Mountain were relatively prominent at the most hospitable end of the nestedness analysis, comprising two of the first four positions, and three of the top eight. The three low domes identified as group D in the classification were identified as the least hospitable parts of the range. Their classification as a separate group is best explained by their depauperate floras, which are a subset of the vegetation of peaks in group C.

Patterns among habitat units on and around the peaks

Drilling down beneath the peak-scale, to assess similarities between the geomorphic habitat units discriminated during the surveys, suggested three primary Habitats:

Habitat 1. Grassy woodlands surrounding most peaks;
Habitat 2. A mixture of dry rainforest elements and grassy woodland, and;
Habitat 3. Rocky shrublands and low woodlands, mainly on upper slopes and summits of trachyte peaks.

Photographs of examples of each of the Habitats appear as Figure 4. The vegetation samples classified together as Habitat 1 included all of those of basalt context adjacent to peaks (Figure 5). This shows that vegetation on basalt adjacent to the peaks is consistently distinguishable from that on the peaks (Habitats 1 & 2). The vegetation in Habitat 1 was typically grassy eucalypt woodland (mainly *Eucalyptus orgadophila, Eucalyptus crebra* and *Corymbia erythrophloia*) and the landform was typically undulating basalt plain. Common grasses include *Heteropogon contortus, Bothriochloa ewartiana, Aristida latifolia, Themeda triandra* and *Dichanthium sericeum*; all of which were much less frequent in Habitats 2 and 3 (Table 2). A few samples from the peaks were also classified into Habitat 1, but they were all grassy woodlands of *Eucalyptus crebra* and occurred on the toe-slopes of The Woolbale, Rocky Knob and Mt Castor.

Habitat 2 occurred on most of the peaks in the northern part of the range, the basalt hills from the central section, and the lower slopes of some of the southern trachyte/rhyolite peaks. Many of the species that differentiate Habitat 2 are associated with dry rainforests in the region (Table 2). Running the habitat classification after excluding species with high fidelity to rainforests produced limited change in classification at the three-group level, and suggests there are other differences. The main change was for the basalt hills, which were classified among the context sites in Habitat 1 when rainforest species were removed.

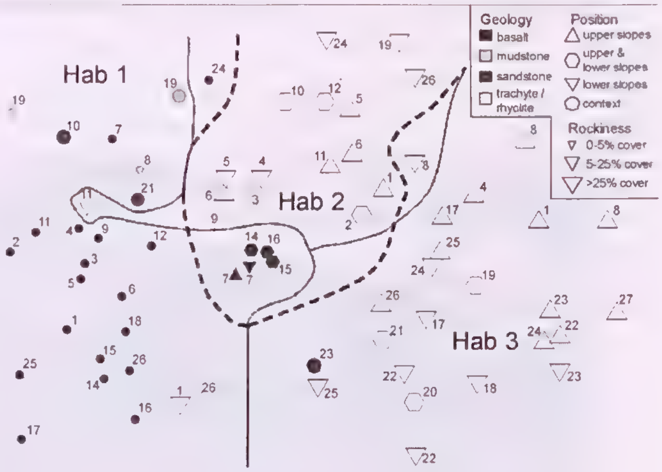

Fig. 5. Two-dimensional ordination (NMDS) of Bray-Curtis similarity in native flora, for habitats across the Peak Range. Symbols differentiates geology (shading), position on peaks (shape), and rockiness (size). Labels identify peaks according to the key provided in Figure 1. Lines differentiate three habitat groups identified by classification (UPGMA) based on all native plants (solid and dashed lines) or based on natives other than rainforest plants (solid and fine-dotted lines).

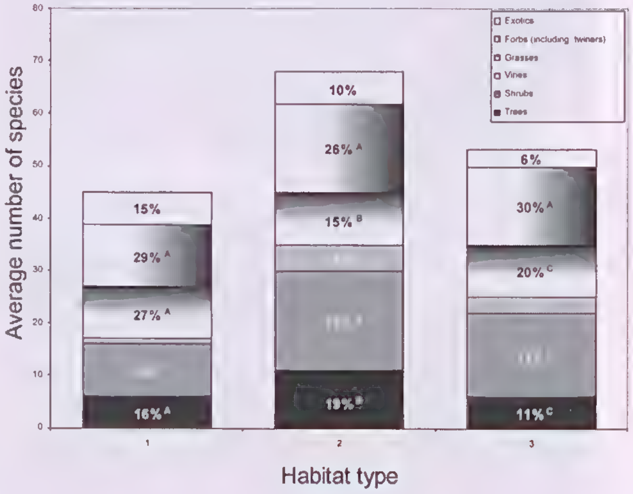

Fig. 6. Average plant species richness by life-form for three Habitats in the Peak Range. Standard Errors for the mean of total native species richness were 2.2, 5.4 and 3.1 for Habitats 1, 2 and 3 respectively. Labels are percentages of native species richness for life-form; superscript "A", "B" and "C" denote significant pairwise differences between habitats (Wilcoxon rank-sum tests) where Kruskal-Wallis tests suggested significant differences across all habitats.

Habitat 2 is a fine scale mosaic of at least two or three distinct plant communities; including grassy woodlands, dry rainforest patches, and shrublands or low woodlands on lithosols. The grassy woodlands in Habitat 2 are most similar to Habitat 1, but there are clear compositional differences. Moving from Habitat 1 to 2 is associated with declining frequency for grassy woodland species such as *Dichanthium sericeum*, *Bothriochloa ewartiana*, *Brunoniella australis* and *Atalaya hemiglauca* and increasing frequency of other plants common in grassy woodlands on the peaks, such as *Cymbopogon queenslandicus* and *Hibiscus sturtii* (Table 2). Likewise, Habitats 2 and 3 share many frequent species but there is a suite of species that differentiates them. Those whose presence indicates Habitat 2 are most common in grassy woodlands (e.g. *Themeda triandra* and *Melhania oblongifolia*) or associated with rainforest patches (e.g. *Alectryon connatus* and *Bridelia leichhardtii*), and those that indicate Habitat 3 are most common in rocky shrublands and open woodlands (e.g. *Acacia julifera* and *Cleistochloa subjuncea*).

At the other end of the spectrum, the samples classified into Habitat 3 included the upper slopes of all of the southern trachyte/rhyolite peaks and of some of the larger such peaks in the north of the range (Mt Donald, Mt Castor and Mt Saddleback). Lower slopes of most of the southern trachyte/rhyolite peaks were also included in this Habitat, but were placed close together on the ordination suggesting some subtle differences with the upper slopes. The vegetation in Habitat 3 was typically mid-dense to dense shrubland, most commonly dominated by *Acacia julifera* subsp. *curvinervia, Dodonaea lanceolata* subsp. *subsessilifolia, Leptospermum lamellatum* and *Xanthorrhoea johnsonii,* with emergent low trees, commonly *Corymbia trachyphloia, Eucalyptus exserta* or *Eucalyptus crebra*. The herbs in Habitat 3 were quite distinct from those in the other two Habitats. Frequent species with the highest fidelity included *Scleria sphacelata, Cheilanthes sieberi, Digitaria breviglumis, Cleistochloa subjuncea, Arundinella nepalensis* and *Triodia pungens*.

In terms of total flora, the peaks supported many more species that were not recorded in the surrounding habitat-matrix than vice-versa. Of 418 species (29 exotic) encountered in the surveys, 192 of them were recorded only on peaks; whereas, only 40 species (five exotic) were recorded adjacent to peaks but not on them. The same pattern occurred for families, with 22 families recorded on the peaks but not the matrix, and only four families found in the matrix unrecorded on the peaks. Families with the most species were very similar on both the peaks and the surrounding landscape. The seven most speciose families in both were Poaceae, Fabaceae, Asteraceae, Mimosaceae, Euphorbiaceae, Myrtaceae and Malvaceae, but their order varied slightly. At the family level the greatest change from the matrix onto the peaks was increasing richness among Cyperaceae, Lamiaceae and Adiantaceae, and the addition of a suite of families represented by one or two rainforest species.

Habitat samples on the peaks had much greater average plant species richness than those adjacent to the peaks (Habitat 2&3 >> Habitat 1, $p = 0.0005$, Figure 6). Within Habitat 2, the habitat samples from steep-sided basalt peaks had much higher average richness than those from trachyte/rhyolite peaks (87 vs. 53 species).

Exotic plants account for only 7% of the flora in the Peak Range. The most abundant is red natal grass, *Melinis repens*. It is the only weed that is abundant on the shallow soils that support the most unique components of the Peak Range's flora. It was the dominant grass on rocky parts of many peaks, particularly in the southern part of the range (peaks in Groups 3&4). Generally the weediness of the flora was greatest off the peaks, equivalent to 15% of the native flora in Habitat 1, and declined with increasing rockiness to about 5% of the number of native species in Habitat 3. Several weed species were associated with shadier, fire-protected pockets most prevalent in Habitat 2, including *Bidens bipinnata, Opuntia tomentosa* and *Solanum seaforthianum*. Buffel grass, *Pennisetum ciliare*, was frequent around the peaks and in Habitat 2, but was rarely dominant. Mt Lowe, in the southern part of the range is completely infested by buffel grass. It was excluded from the analyses in this report because of its weediness.

The three Habitats differ considerably in terms of plant life-forms. The main difference is that the vegetation on the peaks supports many more woody plant species than the vegetation around them. Trees, shrubs and vines all accounted for a much larger proportion of the total flora in the two Habitats on the peaks (Figure 6).

Discussion

The Peak Range is typical of Australian outcrop archipelagos in sharing considerable similarity with the surrounding matrix at the family level, but exhibiting some marked contrasts at the species level (Clarke 2002a). Other similarities with Australian rock outcrop systems include: a lack of highly specialised, often succulent, plant life forms found on some outcrops internationally (Porembski and Barthlot 2000); the presence of resurrection ferns in the genus *Cheilanthes*; the presence of a small number of succulent species uncommon in the surrounding matrix (e.g. *Portulaca bicolor* and *Hoya australis*); the presence of several endemic species restricted to the rock outcrops and; the presence of several plant populations well beyond the core of their geographic range (Hopper *et al.* 1997, Clarke 2002a).

The Peak Range contributes significantly to botanical diversity in its region because overlap between the species found on peaks and in the surrounding basaltic landscape is strongly asymmetric, and because the floras of the peaks are richer than on adjacent landforms. This level of distinctness between the flora of a set of rocky habitat islands and the surrounding matrix is perhaps unusually high for Australian

Table 2. Frequencies in Peak Range habitat groups of species that distinguish the habitat groups. Shaded cells indicate pairwise habitat comparisons for which each species was among the strongest contributors to dissimilarity, with black cells showing increasing frequency upslope and grey indicating decreasing frequency.

Species	1 vs. 2	1 vs. 3	2 vs. 3	% Hab 1	% Hab 2	% Hab 3
Alphitonia excelsa	■	■		15	90	96
Heteropogon contortus		▒	▒	88	65	26
Scleria sphacelata		■	■	0	30	87
Pandorea pandorana	■		▒	27	85	43
Ehretia membranifolia		▒	▒	54	80	4
Brachychiton australis	■		▒	15	80	26
Alectryon connatus	■		▒	8	80	13
Bridelia leichhardtii	■		▒	0	80	9
Cheilanthes sieberi/nudiuscula		■	■	0	25	78
Erythroxylum australe	■	▒	▒	50	75	43
Carissa ovata		▒	▒	50	75	13
Ficus rubiginosa	■		▒	0	75	26
Digitaria breviglumis		■	■	0	25	74
Enneapogon lindleyanus	▒	▒		73	55	35
Atalaya hemiglauca	▒	▒		73	25	4
Bothriochloa ewartiana	▒	▒		73	25	0
Alstonia constricta	■		▒	38	70	48
Cleistochloa subjuncea		■	■	0	10	70
Brunoniella australis	▒	▒		69	40	35
Themeda triandra	▒	▒		65	50	26
Maytenus disperma	■	■		4	60	65
Jasminum didymum	■		▒	35	65	22
Secamone elliptica	■		▒	15	65	26
Dichanthium sericeum	▒	▒		65	25	0
Croton phebalioides	■		▒	12	65	4
Acacia julifera subsp. *curvinervia*		■	■	0	0	65
Corymbia trachyphloia		■	■	0	20	61
Arundinella nepalensis		■	■	0	0	61
Dodonaea lanceolata var. *subsessilifolia*		■	■	0	0	61
Xanthorrhoea johnsonii		■	■	0	0	61
Amaranthus mitchellii/interputus	■		▒	27	60	30
Alyxia ruscifolia	■		▒	0	60	43
Ancistrachne uncinulata	■		▒	12	60	13
Ficus opposita	■		▒	4	60	17
Melhania oblongifolia		■		58	50	9
Corymbia erythrophloia	▒	▒		58	45	0
Aristida latifolia	▒	▒		58	5	4
Cyanthillium cinereum		■	■	15	35	57
Panicum effusum		■	■	12	30	57
Leptospermum lamellatum		■	■	0	30	57
Cymbopogon queenslandicus		■		12	55	52
Psydrax johnsonii	■			15	55	43
Hibiscus sturtii	■			4	55	43
Abutilon spp.	■		▒	19	55	0
Drypetes deplanchei	■		▒	0	55	17
Plumbago zeylanica	■		▒	4	55	9
Aristida ramosa		▒		54	50	4
Psydrax saligna		■		4	25	52
Eucalyptus exserta		■	■	0	10	52
Eucalyptus crebra	▒	▒		50	40	48
Capparis lasiantha	■		▒	38	50	4
Trema tomentosa	■		▒	0	50	26

outcrop archipelagos, especially given its quite low rainfall. Generally, the overlap between floras on rock outcrops and the surrounding matrix increases as rainfall decreases (Hopper *et al.* 1997, McGann 2002). Clarke (2002b) found granite outcrops in the New England Tableland bioregion in eastern Australia, with rainfall between 750 mm and 1250 mm per annum, shared more species with their forest surrounds than vice versa; the opposite of the pattern found in the Peak Range. The geological contrast between the outcrops and matrix in the Peak Range are more substantial than in the granite system reported on by Clarke (2002b), however even the basalt peaks in this study were distinct from their surrounds, confirming that landform is itself important to the distinctiveness of the vegetation on the peaks (Clarke 2002a).

Species that were recorded only on the peaks and not on the surrounding plains fall into two broad classes; species associated with shrublands and low open woodlands on rock pavements and lithosols, and species associated with dry rainforest in fire protected pockets associated with cliffs and scree on the peaks. These two groups strongly influenced vegetation similarity between peaks. Both groups are highly dissimilar at the generic level to the flora of the basaltic terrain around the peaks, and the dry rainforest plants make the flora of Habitat 2 quite distinct at the plant family level.

The endemic plants of the Peak Range are mainly associated with rocky terrain. This is the case for *Acacia arbiana,* and *Plectranthus actites* as well as the un-named *Acacia* from Gemini Peaks, the potentially new *Acacia* from Mt Donald and the two potentially new *Plectranthus* species from The Woolbale and Mt Donald. This substantial list, to which *Trioncinia patens* must also be added, highlights the importance of the Peak Range to regional botanical diversity, but this importance is also clear in the whole flora.

The much greater species richness of the peaks compared to the matrix is most likely because of greater fine-scale habitat diversity on the peaks, due to the influence of geomorphic variation (slopes, summits, cliff-breaks, and rock-slabs) on key physical processes such as water movement, soil development and fire behaviour.

Much of the marked increase in woody plants between the matrix and the peaks is probably related to fire protection, especially for Habitat 2 with its characteristic component of plants associated with dry rainforest. Protection from high fire frequency, provided in the Peak Range by rocky outcrops, gullies and scree-slopes, is key habitat-component for dry rainforest plants in Central Queensland (Fensham 1995). The shrubby vegetation associated with rocky and shallow soils in Habitat 3 typically includes fewer trees than Habitat 2 does, but still supports many more woody species than the vegetation surrounding the peaks in Habitat 1. Shrubs are often prominent on shallow soils associated with rock outcrops in Australia (Clarke 2002a), probably because the soils are too shallow and freely draining to support trees. The trees that do occur in Habitat 3 (*Eucalyptus exserta* and *Corymbia trachyphloia*) also often occur on shallow well-drained soils in sandstone landscapes.

The connection between the flora of sandstone landscapes and the southern trachyte peaks, predominant in Habitat 3, is particularly clear on Scotts and Ropers Peaks, which have a skirt of sandstone around their base and support several species more typically found on sandstone, including *Acacia gnidium, Dampiera discolor, Lysicarpus angustifolius, Persoonia amaliae* and *Prostanthera leichhardtii.* Other sandstone-associated scleromorphic species occur more broadly across the Peak Range, generally on the upper slopes and shallow rocky soils, such as *Cleistochloa subjuncea, Corymbia trachyphloia, Leptospermum lamellatum, Triodia pungens* and *Xanthorrhoea johnsonii.* Whether this connection with the region's sandstone flora has more to do with water and freely draining soils, or rock type and lower pH and nutrient status, is an interesting but open question. The association of Habitat 3 with the run-off areas on upper slopes suggests that drainage is perhaps the key feature, but drought and soil nutrition are clearly not mutually exclusive factors and weighing their relative importance will be difficult. Our impression is that beyond a weak association between substantial rainforest development and south and easterly aspects (in run-on topographic positions), there does not appear to be a strong effect of aspect on vegetation in the Peak Range.

Consequences for conservation and management

The Peak Range contains at least three, quite distinct botanic and geographic sections: the northern and southern trachyte features and the central basalt hills. The current extent of the Peak Range National Park covers sections of the northern trachyte/rhyolite peaks and the central basalt hills, including many of the peaks highlighted as most hospitable to plant diversity in the Peak Range by analysis of nestedness. However, the National Park does not include any part of the southern end of the range, which appears to be its most distinctive section. Consideration may be given to adding some of the southern peaks to the Peak Range National Park, however the Peak's generally rocky and steep geomorphology lends most of them considerable protection from grazing and there are no threats that would obviously be alleviated by placing the peaks within a conservation reserve.

The best conservation strategy is likely to revolve around working with landholders to manage threats. Buffel grass probably represents the greatest potential threat to the native vegetation of the Peak Range, particularly to fire-sensitive dry rainforest species. Buffel grass seems to be implicated in a grass-fire cycle (D'Antonio and Vitousek 1992). The growth potential of buffel grass seems to increase the susceptibility of dry rainforest to incursion by fire (sensu Panton 1993). It is difficult to envisage effective control of *Melinis repens*, given its wind-dispersal and the extent of the infestation.

Feral animals currently seem to pose little threat. We saw only limited sign of pigs and the range is remarkable in the absence of feral goats that plague so many other rocky habitats in semi-arid Australia.

Cattle grazing may be an issue for *Trioncinia patens*, which is arguably the most threatened plant species in the Peak Range. Two of the three known populations of *Trioncinia patens* occur within the Peak Range NP (Holland and Butler 2007). *Trioncinia retroflexa,* the closest relative of *Trioncinia patens*, is highly sensitive to continuous grazing (Fensham *et al.* 2002). Two of the populations of *Trioncinia patens* are currently exposed to low levels of grazing at the base of Browns and Eastern Peaks. Intensification of grazing in these areas should be avoided, particularly during the summer when the species flowers and seeds.

Methodological considerations

The traverse-survey method employed in this study provided sufficient information to describe relationships among peaks, identify broad habitat types, and identify differences between the vegetation of the peaks and that of the surrounding landscape matrix. The main short-coming of the method concerns resolution of the habitat units, particularly in Habitat 2 which clearly included several quite distinct vegetation classes that would perhaps have been discriminated using plot based survey techniques. However, a plot-based survey would have to have been extensive to overcome this problem, especially with random plot placement. A very substantial advantage with our technique is that comprehensive survey data, including information on rare species, is attainable with a reasonable effort: in this case, survey of 25 separate peaks in 12 days field work.

In Australia, 'plotless' vegetation surveys have most widely been used in rainforest. For example, the seminal work of Webb, Tracey and Williams (1984) as well as that of Russell-Smith (1991) and Fensham (1995), were all based on plotless inventories. The technique is also well suited to rock outcrop surveys, not least because the patchy nature of rock-outcrop vegetation, including large areas of bare rock, can be problematic for plot based surveys. Another important feature of the survey technique employed here, which is recommended for any survey of poorly known rock outcrop vegetation, is including the 'matrix' in the survey, enabling comparisons across outcrop boundaries.

Conclusions

The Peak Range harbours several endemic plants among a diverse flora which is clearly distinct from that of the surrounding terrain. The distinctiveness of the range's flora is due to two habitat components: dry rainforest patches reliant upon fire protection afforded by the peaks, and a scleromorphic flora associated with shallow soils and rock pavements. The endemic species of the Peak Range are mainly associated with the latter of these, which lends them considerable natural protection from potential threats, including fire and grazing.

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Appendix – Plants of the Peak Range. Names of exotic species are preceded by '*'. Life form codes are f – forb, g – grass, s – shrub, t – tree, v – vine, w - twiner. '(rf)' indicates 'rainforest species'. The remaining columns detail numbers of records from various sources: 'n Peaks' is the number of Peaks from which a taxon is known (from any of the sources used); 'n Context' is the number of context sites in which each taxa was encountered in this survey; 'Fensham & Holman' indicates those species recorded from Lord's Table Mountain in the surveys of Fensham and Holman (1998); 'Fensham's Dry RF' indicates species recorded from dry rainforest on Lords Table Mountain in the survey by Fensham (1995); 'HERBRECS' is the number of specimen records from peaks in the Peak Range held at the Queensland Herbarium prior to this survey. Nomenclature after Bostock and Holland (2007).

	Life form	**n Peaks**	**n Context**	**Fensham & Holman**	**Fensham's Dry RF**	**HERBRECS**
Angiosperms						
Acanthaceae						
Brunoniella australis	f	19	16	1	-	-
Pseuderanthemum variabile	f	8	1	1	1	2
Rostellularia adscendens	f	6	4	-	-	-
Aizoaceae						
Zaleya galericulata	f	2	5	-	-	-
Amaranthaceae						
Achyranthes aspera	f	12	6	1	-	-
Alternanthera denticulata	f	2	-	1	-	1
Alternanthera nana	f	7	-	1	-	1
Amaranthus mitchellii and/or *A. interruptus*	f	20	6	-	-	-
Deeringia amaranthoides	f	4	-	-	1	-
Nyssanthes erecta	f	1	4	-	-	-
Anacardiaceae						
Euroschinus falcatus var. *angustifolius*	t (rf)	19	-	1	1	2
Apiaceae						
Platysace valida	s	8	-	-	-	-
Apocynaceae						
Alstonia constricta	t	28	9	1	1	-
Alyxia ruscifolia	s (rf)	26	-	1	1	2
Carissa ovata	s	20	12	1	1	-
Cerbera dumicola	t	1	-	-	-	-
Parsonsia lanceolata	v	13	3	1	1	-
Parsonsia plaesiophylla	v (rf)	13	-	1	1	1
Parsonsia rotata	v (rf)	1	-	-	-	1
Araliaceae						
Polyscias elegans	t (rf)	9	-	1	1	1
Asclepiadaceae						
**Gomphocarpus physocarpus*	f	-	-	-	-	-

	Life form	n Peaks	n Context	Fensham & Holman	Fensham's Dry RF	HERBRECS
Hoya australis	v	10	-	1	1	-
Marsdenia microlepis	v	20	3	1	-	1
Marsdenia pleiadenia	v (rf)	2	1	-	1	-
Marsdenia viridiflora subsp. *viridiflora*	v	2	1	1	-	-
Sarcostemma viminale subsp. *brunonianum*	s	5	-	-	-	-
Secamone elliptica	v	23	3	1	1	1
Tylophora erecta	s	3	-	-	-	-
Asteraceae						
Acmella grandiflora var. *brachyglossa*	f	2	-	1	-	1
**Bidens bipinnata*	f	-	3	1	-	1
Brachyscome microcarpa	f	2	-	1	-	1
Calotis cuneata	f	-	2	-	-	-
Calotis lappulacea	f	3	2	-	-	1
Cassinia laevis	s	4	-	-	-	-
Chrysocephalum apiculatum	f	2	-	1	-	1
**Conyza aegyptiaca*	f	-	-	-	-	-
**Conyza bonariensis*	f	-	-	-	-	-
Cyanthillium cinereum	f	21	4	1	-	-
**Emilia sonchifolia*	f	-	1	-	-	-
Epaltes australis	f	2	-	1	-	1
Glossocardia bidens	f	2	-	1	-	1
Gynura drymophila	f	1	-	-	-	-
Olearia canescens	s	1	-	-	-	-
**Parthenium hysterophorus*	f	-	19	1	-	-
Peripleura bicolor	f	4	1	-	-	-
Peripleura diffusa	f	1	-	-	-	-
Peripleura hispidula	f	12	6	1	-	1
Pluchea dentex	f	1	1	-	-	-
Pseudognaphalium luteoalbum	f	1	-	-	-	1
Pterocaulon redolens	f	1	-	-	-	1
Pterocaulon serrulatum var. *serrulatum*	f	5	-	-	-	-
Pterocaulon sphacelatum	f	8	-	1	-	1
**Schkuhria pinnata*	f	-	1	1	-	1
Senecio bathurstianus	f	1	-	-	-	-
Senecio brigalowensis	f	1	-	-	-	1
Sigesbeckia fugax	f	2	-	-	-	-
Sigesbeckia orientalis	f	8	-	1	-	1
**Sonchus oleraceus*	f	-	-	-	-	1
**Tagetes minuta*	f	-	-	1	-	1
**Tridax procumbens*	f	-	-	-	-	1
Trioncinia patens	f	1	2	-	-	1
Vittadinia pterochaeta	f	2	-	1	-	1
Vittadinia sulcata	f	2	-	1	-	1
Wedelia spilanthoides	f	4	2	-	-	-
Xerochrysum bracteatum	f	16	4	1	-	3
**Zinnia peruviana*	f	-	1	-	-	-
Bignoniaceae						
Pandorea pandorana	v	30	5	1	-	-
Boraginaceae		-	-	-	-	-
Ehretia membranifolia	s	20	12	-	-	1
**Heliotropium amplexicaule*	f	-	-	-	-	-
Heliotropium brachygyne	f	2	-	1	-	1
Trichodesma zeylanicum	f	4	2	-	-	1
Cactaceae						
**Opuntia stricta*	s	-	-	1	-	-
**Opuntia tomentosa*	s	-	9	1	1	-
Caesalpiniaceae						
Cassia brewsteri	s	10	8	-	-	-
Chamaecrista absus var. *absus*	f	6	3	1	-	1
Chamaecrista mimosoides	f	2	-	1	-	1
Chamaecrista nomame	f	1	-	-	-	-
Lysiphyllum carronii	t	2	5	-	-	-
Senna aciphylla	s	4	1	-	-	1
Senna barclayana	s	2	-	-	-	-
Senna gaudichaudii	s	2	-	-	-	1
Senna artemisioides nothosubsp. *coriacea* (formerly *Senna nemophila*)	s	-	1	-	-	-
Senna surattensis subsp. *retusa*	s	1	-	1	-	-
Campanulaceae						
Isotoma axillaris	f	1	-	-	-	1
Lobelia quadrangularis	f	2	-	1	-	1
Wahlenbergia gracilis	f	9	-	1	-	1
Capparaceae						
Apophyllum anomalum	s	-	3	-	-	-
Capparis arborea	s (rf)	1	-	1	-	-
Capparis canescens	s	12	8	-	-	-
Capparis lasiantha	w	12	9	-	-	-
Capparis loranthifolia	s (rf)	7	1	-	-	1
Capparis mitchellii	s	-	1	-	-	-
Cleome viscosa	f	16	6	-	-	-
Caryophyllaceae						
Polycarpaea corymbosa	f	5	-	-	-	-
Polycarpaea spirostylis	f	2	-	-	-	1
Celastraceae						
Denhamia oleaster.	s	11	10	-	1	-
Elaeodendron australe	s	5	1	-	1	1
Maytenus cunninghamii	s	12	12	-	-	1
Maytenus disperma	s	29	2	1	1	1
Chenopodiaceae						
Atriplex muelleri	f	1	1	-	1	-
Chenopodium pumilio	f	1	-	-	-	-

	Life form	n Peaks	n Context	Fensham & Holman	Fensham's Dry RF	HERBRECS
Einadia hastata	f	4	-	-	-	-
Einadia nutans	f	10	2	-	-	-
Salsola kali	f	1	13	-	-	-
Sclerolaena anisacanthoides	f	-	2	-	-	-
Sclerolaena bicornis	f	-	3	-	-	-
Sclerolaena muricata	f	-	3	-	-	-
Clusiaceae						
Hypericum gramineum	f	1	-	-	-	-
Hypericum japonicum	f	1	-	1	-	-
Colchicaceae						
Iphigenia indica	f	2	-	1	-	1
Combretaceae						
Terminalia oblongata	s	1	7	-	-	1
Commelinaceae						
Commelina ensifolia	f	21	2	1	-	-
Murdannia graminea	f	1	-	-	-	-
Convolvulaceae						
Dichondra repens	f	1	-	1	-	-
Evolvulus alsinoides	f	18	5	1	-	-
Ipomoea brownii	w	6	2	-	-	-
Ipomoea calobra	w	2	-	-	-	-
Ipomoea gracilis	w	1	-	-	-	-
Ipomoea plebeia	w	4	2	1	-	-
Ipomoea polymorpha	w	2	-	1	-	1
Jacquemontia paniculata	f	5	6	-	-	1
Polymeria pusilla	f	-	1	-	-	-
Crassulaceae						
*_Bryophyllum delagoense_	f	-	-	1	1	2
Cucurbitaceae						
Cucumis melo	w	1	-	-	-	-
Mukia maderaspatana	w	2	-	-	-	-
Sicyos australis	w (rf)	3	-	-	-	-
Cyperaceae						
Bulbostylis barbata	f	2	-	-	-	-
Cyperus bifax	f	1	2	1	-	-
Cyperus concinnus	f	2	-	1	-	1
Cyperus cunninghamii subsp. _cunninghamii_	f	1	-	-	-	-
Cyperus dietrichiae var. _dietrichiae_	f	1	-	-	-	1
Cyperus difformis	f	1	-	1	-	-
Cyperus fulvus	f	8	-	1	-	1
Cyperus gracilis	f	5	1	1	1	1
Cyperus leiocaulon	f	3	-	-	-	-
Cyperus microcephalus subsp. _microcephalus_	f	9	-	-	-	-
Cyperus squarrosus	f	2	-	1	-	1
Fimbristylis dichotoma	f	15	-	1	-	-

	Life form	n Peaks	n Context	Fensham & Holman	Fensham's Dry RF	HERBRECS
Lipocarpha microcephala	f	2	-	1	-	1
Schoenus vaginatus	f	2	-	-	-	-
Scleria mackaviensis	f	10	2	1	1	-
Scleria sphacelata	f	27	1	-	-	2
Dilleniaceae						
Hibbertia stricta	f	5	-	-	-	-
Droseraceae						
Drosera indica	f	1	-	1	-	-
Ebenaceae						
Diospyros humilis	t (rf)	13	2	1	1	1
Erythroxylaceae						
Erythroxylum australe	s	30	10	1	-	2
Euphorbiaceae						
Acalypha eremorum	s (rf)	9	2	1	1	1
Bertya pedicellata	s	22	-	-	-	7
Beyeria viscosa var. _obovata_	s	3	-	-	-	-
Breynia oblongifolia	s	14	-	1	1	-
Bridelia leichhardtii	t (rf)	20	-	1	1	-
Chamaesyce biconvexa	f	1	-	-	-	1
Chamaesyce coghlanii	f	2	7	-	-	-
Chamaesyce dallachyana	f	2	-	-	-	-
Chamaesyce drummondii	f	1	-	1	-	-
*_Chamaesyce hirta_	f	-	-	-	-	-
*_Chamaesyce hyssopifolia_	f	-	-	-	-	-
Chamaesyce mitchelliana	f	2	-	-	-	-
Croton phebalioides	s (rf)	17	3	-	1	2
Drypetes deplanchei	t (rf)	20	-	1	1	3
Euphorbia tannensis subsp. _eremophila_	f	3	-	1	-	1
Flueggea leucopyrus	s (rf)	14	12	1	-	2
Leptopus decaisnei var. _decaisnei_	f	-	1	-	-	-
Monotaxis macrophylla	f	1	-	-	-	-
Petalostigma pubescens	t	5	4	-	-	-
Phyllanthus maderaspatensis	f	2	4	-	-	1
Phyllanthus virgatus	f	15	7	1	-	1
Poranthera microphylla	f	1	-	1	-	-
Sauropus trachyspermus	f	-	1	-	-	-
Fabaceae						
Aeschynomene brevifolia	f	1	-	-	-	-
Alysicarpus muelleri	f	-	1	-	-	-
Cajanus reticulatus var. _reticulatus_	w	2	1	-	-	-
Canavalia papuana	w	1	-	-	-	-
Crotalaria brevis	f	1	-	-	-	-
*_Crotalaria incana_ subsp. _incana_	f	-	3	1	-	1
*_Crotalaria juncea_	f	-	1	1	-	-
Crotalaria medicaginea var. _medicaginea_	f	-	1	-	-	-

	Life form	n Peaks	n Context	Fensham & Holman	Fensham's Dry RF	HERBRECS
Crotalaria montana	f	1	-	-	-	1
Daviesia filipes	s	3	-	-	-	-
Desmodium brachypodum	w	3	2	-	-	-
Desmodium campylocaulon	w	-	2	-	-	-
Desmodium gunnii	w	1	-	1	-	-
Desmodium rhytidophyllum	w	5	-	1	-	1
Desmodium varians	w	2	-	1	-	-
Erythrina vespertilio	t	7	3	-	-	-
Galactia sp. indet.	w	1	-	-	-	1
Galactia tenuiflora	w	13	9	1	-	-
Gastrolobium grandiflorum	f	1	-	-	-	1
Glycine latifolia	w	-	2	-	-	-
Glycine tabacina	w	2	-	1	-	1
Glycine tomentella	w	2	-	1	-	1
Hardenbergia perbrevidens	w	6	-	-	-	1
Hovea longipes	s	14	1	-	-	1
Hovea tholiformis	s	1	-	-	-	-
Indigastrum parviflorum	f	2	-	1	-	1
Indigofera australis	s	12	4	-	-	-
Indigofera brevidens	s	12	1	-	-	1
Indigofera colutea	s	1	1	-	-	-
Indigofera hirsuta	s	4	-	1	-	1
Indigofera linifolia	s	5	6	-	-	-
Indigofera linnaei	s	3	2	1	-	-
Indigofera pratensis	s	4	3	-	-	-
Indigofera sp. indet.	s	-	1	-	-	-
Jacksonia scoparia	s	3	-	-	-	-
**Macroptilium lathyroides*	w	-	1	-	-	-
Rhynchosia minima	w	8	10	1	-	-
**Stylosanthes scabra*	f	-	-	-	-	-
Tephrosia astragaloides	s	1	-	-	-	-
Tephrosia barbatula	s	2	1	-	-	-
Tephrosia filipes subsp. *filipes*	s	2	-	1	-	1
Tephrosia sp. (Ilfracombe R.D.Law AQ238393)	s	1	-	-	-	-
Tephrosia sp. (Miriam Vale E.J.Thompson+ MIR33)	s	1	-	-	-	1
Vigna lanceolata	w	2	-	-	-	-
Vigna radiata	w	2	2	-	-	1
Zornia muriculata subsp. *muriculata*	f	2	-	1	-	1
Goodeniaceae						
Dampiera discolor	f	7	1	-	-	1
Goodenia grandiflora	f	5	-	1	-	2
Goodenia rotundifolia	f	5	-	-	-	-
Haloragaceae						
Gonocarpus teucrioides	f	3	-	-	-	-

	Life form	n Peaks	n Context	Fensham & Holman	Fensham's Dry RF	HERBRECS
Hemerocallidaceae						
Dianella brevipedunculata	f	1	-	-	-	-
Dianella caerulea	f	6	-	1	-	1
Dianella longifolia	f	7	1	-	-	-
Dianella nervosa	f	1	-	-	-	1
Tricoryne elatior	f	4	-	1	-	1
Hypoxidaceae						
Hypoxis arillacea	f	1	-	-	-	1
Hypoxis hygrometrica var. *villosisepala*	f	2	-	1	-	1
Juncaceae						
Juncus aridicola	f	2	-	1	-	1
Lamiaceae						
Anisomeles malabarica	f	2	-	-	-	2
Clerodendrum floribundum	s	12	4	1	-	1
Mentha grandiflora	f	9	1	-	-	-
Plectranthus actites	f	4	-	1	1	2
Plectranthus graveolens	f	11	-	-	-	1
Plectranthus parviflorus	f	1	-	-	-	1
Plectranthus sp. nov. 1?	f	1	-	-	-	-
Plectranthus sp. nov. 2?	f	1	-	-	-	-
Prostanthera leichhardtii	s	5	1	-	-	2
Prostanthera lithospermoides	s	2	-	-	-	-
Spartothamnella juncea	s	2	-	-	-	-
Lauraceae						
Cassytha pubescens	f	-	1	-	-	-
Laxmanniaceae						
Eustrephus latifolius	w	14	5	1	-	1
Lomandra filiformis	f	2	-	-	-	-
Lomandra longifolia	f	11	2	1	-	1
Lomandra multiflora subsp. *multiflora*	f	1	-	-	-	-
Loranthaceae						
Amyema villiflora	f	1	-	-	-	1
Lythraceae						
Ammannia multiflora	f	2	-	1	-	1
Rotala mexicana	f	2	-	1	-	1
Malvaceae						
Abelmoschus ficulneus	f	-	1	-	-	-
Abutilon auritum and/or *A.. leucopetalum* and/or *A. micropetalum* and/or *A. nobile*	f	14	8	-	1	4
Abutilon otocarpum	f	7	1	-	-	-
Abutilon oxycarpum	f	8	3	1	-	1
Gossypium australe	f	2	2	-	-	-
Hibiscus heterophyllus	s	10	-	-	-	-
Hibiscus meraukensis	s	2	-	-	-	-
Hibiscus sturtii	s	22	2	1	-	1
Hibiscus trionum var. *vesicarius*	f	2	4	1	-	-

	Life form	n Peaks	n Context	Fensham & Holman	Fensham's Dry RF	HERBRECS
Hibiscus vitifolius	s	1	-	-	-	-
**Malvastrum americanum*	f	-	17	1	-	-
Sida atherophora	f	3	2	-	-	-
Sida fibulifera	f	2	4	-	-	-
Sida sp. (cf *S. cunninghamii*)	f	4	2	-	-	-
Sida sp. (Greenvale R.J.Fensham 1150)	f	6	1	-	-	1
**Sida spinosa*	f	-	15	1	-	-
Sida subspicata	f	6	3	1	-	-
Meliaceae						
Melia azedarach	t	9	-	1	1	2
Owenia acidula	t	4	11	-	-	-
Turraea pubescens	t (rf)	10	3	-	1	-
Menispermaceae						
Pleogyne australis	v (rf)	1	1	-	-	-
Stephania japonica	v	2	-	-	1	-
Tinospora smilacina	v	6	-	1	-	-
Mimosaceae						
Acacia amblygona	s	4	-	-	-	1
Acacia aprepta	s	1	-	-	-	-
Acacia arbiana	s	15	-	-	-	5
Acacia bancroftiorum	s	5	1	-	-	-
Acacia bidwillii	s	2	8	-	-	-
Acacia burdekensis	s	1	-	-	-	-
Acacia cretata	s	4	1	-	-	1
Acacia decora	s	7	5	1	-	1
Acacia excelsa	t	3	4	-	-	-
**Acacia farnesiana*	s	-	7	-	-	-
Acacia gnidium	s	7	-	-	-	3
Acacia harpophylla	t	-	6	-	-	-
Acacia julifera subsp. *curvinervia*	s	15	1	-	-	1
Acacia juncifolia	s	2	-	-	-	-
Acacia leiocalyx	s	-	1	-	-	-
Acacia macradenia	s	5	-	-	-	-
**Acacia nilotica*	t	-	1	-	-	-
Acacia rhodoxylon	t	1	1	-	-	-
Acacia salicina	t	8	4	-	-	-
Acacia shirleyi	t	-	1	-	-	-
Acacia sp. (Gemini Peaks)	s	2	-	-	-	-
Acacia sp. (Mt Donald)	s	2	-	-	-	-
Albizia canescens	t	1	-	-	-	-
Archidendropsis basaltica	s	4	5	-	-	-
Archidendropsis thozetiana	t	2	-	-	-	-
Neptunia gracilis	f	1	9	1	-	-
Moraceae						
Ficus obliqua	t (rf)	4	-	1	-	-
Ficus opposita	s	21	1	1	1	3
Ficus rubiginosa	t	25	-	-	1	3
Ficus virens	t (rf)	2	-	1	1	-
Trophis scandens	v (rf)	1	-	-	-	-
Myoporaceae						
Eremophila deserti	s	1	1	-	-	-
Eremophila longifolia	s	1	-	-	-	-
Eremophila mitchellii	s	1	7	-	-	-
Myoporum acuminatum	s	1	1	-	-	-
Myrsinaceae						
Myrsine variabilis	s	6	-	-	1	-
Myrtaceae						
Callistemon sp. (Ropers Peak P.I.Forster PIF7208)	s	12	-	1	-	3
Corymbia citriodora	t	1	-	-	-	-
Corymbia clarksoniana	t	3	-	-	-	-
Corymbia dallachiana	t	8	7	-	-	-
Corymbia erythrophloia	t	10	14	-	-	-
Corymbia leichhardtii	t	10	1	-	-	-
Corymbia peltata	t	5	-	-	-	-
Corymbia tessellaris	t	-	1	-	-	-
Corymbia trachyphloia	t	20	-	-	-	2
Eucalyptus apothalassica	t	4	-	-	-	-
Eucalyptus crebra	t	20	12	-	-	-
Eucalyptus exserta	t	16	-	1	-	1
Eucalyptus melanophloia	t	2	3	-	-	-
Eucalyptus microcarpa	t	2	-	1	-	1
Eucalyptus moluccana	t	1	-	-	-	1
Eucalyptus orgadophila	t	9	12	-	-	2
Eucalyptus populnea	t	-	-	-	-	-
Gossia bidwillii	t (rf)	3	-	1	-	1
Leptospermum lamellatum	s	19	-	-	-	-
Leptospermum neglectum	s	9	-	-	-	-
Lysicarpus angustifolius	t	5	1	-	-	-
Melaleuca bracteata	t	1	1	-	-	-
Nyctaginaceae						
Boerhavia sp. indet.	f	9	10	-	-	-
Oleaceae						
Jasminum didymum	v	18	9	-	-	-
Jasminum simplicifolium	v	18	2	1	1	-
Notelaea microcarpa	s	17	4	1	1	1
Orchidaceae						
Cymbidium canaliculatum	f	2	-	-	-	-
Dockrillia bowmanii	f (rf)	3	-	1	1	1
Sarcochilus ceciliae	f	1	-	-	1	-
Oxalidaceae						
**Oxalis corniculata*	f	1	-	1	-	-
Oxalis sp. indet.	f	13	2	-	-	-
Passifloraceae						
Passiflora aurantia	v	5	-	-	-	-

	Life form	n Peaks	n Context	Fensham & Holman	Fensham's Dry RF	HERBRECS
Pedaliaceae						
Josephinia eugeniae	f	-	2	-	-	-
Piperaceae						
Peperomia blanda var. *floribunda*	f	2	-	-	1	1
Pittosporaceae						
Bursaria incana	s	6	7	-	-	-
Hymenosporum flavum	t (rf)	1	-	-	-	-
Pittosporum spinescens	s	9	10	1	1	-
Plumbaginaceae						
Plumbago zeylanica	f	14	-	-	-	-
Poaceae						
Alloteropsis cimicina	g	6	1	1	-	1
Ancistrachne uncinulata	g	17	3	1	1	-
Aristida benthamii var. *benthamii*	g	7	-	-	-	-
Aristida calycina	g	6	-	1	-	1
Aristida holathera	g	2	-	-	-	1
Aristida ingrata	g	1	-	-	-	1
Aristida jerichoensis	g	2	-	-	-	-
Aristida latifolia	g	3	15	1	-	-
Aristida lazaridis	g	4	4	1	-	1
Aristida leptopoda	g	2	7	1	-	-
Aristida muricata	g	2	-	1	-	1
Aristida personata	g	5	1	-	-	-
Aristida queenslandica	g	16	3	1	-	1
Aristida ramosa	g	14	13	1	-	1
Aristida spuria	g	3	-	1	-	1
Arundinella nepalensis	g	13	1	-	-	-
Astrebla elymoides	g	-	3	-	-	-
Astrebla lappacea	g	1	3	-	-	1
Bothriochloa bladhii	g	1	3	1	-	-
Bothriochloa decipiens var. *cloncurrensis*	g	1	1	-	-	-
Bothriochloa decipiens var. *decipiens*	g	3	-	1	-	1
Bothriochloa erianthoides	g	-	1	-	-	-
Bothriochloa ewartiana	g	8	17	1	-	-
**Bothriochloa pertusa*	g	-	1	-	-	-
Brachyachne convergens	g	-	3	-	-	-
Chloris divaricata	g	2	1	1	-	1
Chloris ventricosa	g	2	4	-	-	-
**Chloris virgata*	g	-	2	-	-	-
Chrysopogon fallax	g	3	-	1	-	-
Cleistochloa subjuncea	g	17	1	-	-	-
Cymbopogon bombycinus	g	18	3	-	-	-
Cymbopogon obtectus	g	3	-	1	-	2
Cymbopogon queenslandicus	g	25	3	1	-	1
Cymbopogon refractus	g	8	1	1	-	-
Dactyloctenium radulans	g	1	3	-	-	-
Dichanthium queenslandicum	g	-	2	-	-	-
Dichanthium sericeum	g	9	16	1	-	2
Dichanthium tenue	g	1	-	-	-	-
Digitaria breviglumis	g	21	1	-	-	-
Digitaria brownii	g	6	-	1	-	2
Digitaria diffusa	g	1	-	-	-	1
Digitaria divaricatissima	g	2	1	1	-	-
Digitaria minima	g	1	-	-	-	1
Digitaria parviflora	g	1	-	-	-	-
Enneapogon gracilis	g	7	11	1	-	2
Enneapogon lindleyanus	g	22	17	1	-	1
Enneapogon pallidus	g	2	-	-	-	-
Enneapogon polyphyllus	g	5	5	-	-	1
Enteropogon acicularis	g	-	4	-	-	-
Enteropogon ramosus	g	5	6	-	-	-
Enteropogon unispiceus	g	1	-	-	-	-
Entolasia stricta	g	1	-	-	-	-
Eragrostis brownii	g	1	-	-	-	-
Eragrostis elongata	g	5	-	1	-	1
Eragrostis lacunaria	g	1	-	-	-	-
Eragrostis leptostachya	g	2	1	-	-	-
Eragrostis megalosperma	g	6	3	-	-	-
Eragrostis sororia	g	5	-	1	-	1
Eremochloa bimaculata	g	-	1	-	-	-
Eriachne mucronata	g	18	1	1	-	2
Eriachne pallescens	g	1	-	-	-	-
Eriochloa crebra	g	4	4	-	-	-
Eriochloa procera	g	8	6	1	-	1
Eriochloa pseudoacrotricha	g	1	-	-	-	-
Eulalia aurea	g	2	1	1	-	-
Heteropogon contortus	g	22	21	1	-	-
Iseilema vaginiflorum	g	2	4	1	-	-
Leptochloa decipiens	g	16	2	1	-	1
**Megathyrsus maximus*	g	-	2	-	-	-
**Melinis repens*	g	-	15	1	-	-
Microlaena stipoides var. *stipoides*	g	2	-	1	-	1
**Moorochloa eruciformis*	g	-	3	-	-	-
Ophiuros exaltatus	g	-	1	-	-	-
Oplismenus aemulus	g	2	-	1	1	-
Panicum decompositum	g	4	9	1	-	1
Panicum effusum	g	20	3	1	-	-
Panicum queenslandicum	g	3	2	1	-	-
Paspalidium albovillosum	g	6	-	-	-	-
Paspalidium caespitosum	g	1	3	-	-	-
Paspalidium constrictum	g	6	2	1	-	1
Paspalidium distans	g	1	-	-	-	-
Paspalidium globoideum	g	-	3	-	-	-

	Life form	n Peaks	n Context	Fensham & Holman	Fensham's Dry RF	HERBRECS
Paspalidium gracile	g	16	1	-	-	1
**Pennisetum ciliare*	g	-	18	-	-	-
Perotis rara	g	4	1	-	-	-
Sarga leiocladum	g	3	1	1	-	-
Setaria australiensis	g	1	-	-	-	-
Setaria paspalidioides	g	1	-	-	-	-
Setaria surgens	g	5	2	-	-	-
Sporobolus actinocladus	g	-	1	-	-	-
Sporobolus caroli	g	-	3	-	-	-
Sporobolus elongatus	g	2	-	1	-	1
Thellungia advena	g	1	5	-	-	-
Themeda triandra	g	18	16	1	-	-
Tragus australianus	g	5	8	1	-	-
Triodia mitchellii	g	5	-	-	-	1
Triodia pungens	g	10	1	-	-	-
Tripogon loliiformis	g	4	-	1	-	-
Urochloa foliosa	g	2	-	1	-	1
Urochloa gilesii	g	2	-	-	-	1
Urochloa holosericea	g	4	-	1	-	1
**Urochloa mosambicensis*	g	-	-	-	-	-
**Urochloa panicoides*	g	-	2	-	-	-
Urochloa pubigera	g	7	2	-	-	-
Polygalaceae						
Polygala linariifolia	f	2	-	1	-	1
Polygala sp. (Emerald R.W.Johnson 1322)	f	-	2	-	-	-
Portulacaceae						
Grahamia australiana	f	4	-	1	-	1
Portulaca australis	f	1	-	-	-	1
Portulaca bicolor	f	10	-	1	-	1
Portulaca filifolia	f	1	-	1	-	-
**Portulaca oleracea*	f	-	9	-	-	-
**Portulaca pilosa*	f	-	-	-	-	-
Proteaceae						
Grevillea parallela	t	1	-	-	-	-
Grevillea striata	t	3	6	-	-	-
Hakea lorea	s	7	1	1	-	-
Persoonia amaliae	s	1	1	-	-	1
Persoonia falcata	s	3	-	-	-	1
Ranunculaceae						
Clematis pickeringii	v	1	-	-	-	-
Rhamnaceae						
Alphitonia excelsa	s	41	4	1	-	-
Ventilago viminalis	t	4	4	-	-	-
Rubiaceae						
Antirhea putaminosa	s (rf)	4	-	-	1	2
Larsenaikia ochreata	s	3	2	-	-	-
Oldenlandia coerulescens	f	1	-	1	-	-
Oldenlandia galioides	f	1	-	1	-	-

	Life form	n Peaks	n Context	Fensham & Holman	Fensham's Dry RF	HERBRECS
Oldenlandia mitrasacmoides	f	3	-	1	-	1
Pavetta australiensis	s (rf)	3	-	-	1	-
Pogonolobus reticulatus	s	3	1	-	-	-
Pomax umbellata	f	5	-	-	-	-
Psychotria daphnoides	s (rf)	5	-	-	-	1
Psychotria daphnoides var. *angustifolia*	s (rf)	5	-	-	1	-
Psydrax forsteri	s	3	-	1	-	2
Psydrax johnsonii	s	23	4	-	-	2
Psydrax odorata	s	2	-	1	-	-
Psydrax oleifolia	s	6	5	-	1	-
Psydrax saligna	s	17	1	-	-	-
Spermacoce sp. indet.	f	15	6	1	-	1
Spermacoce brachystema	f	15	6	-	-	1
Triflorensia ixoroides	s (rf)	4	-	-	-	1
Rutaceae						
Acronychia laevis	s (rf)	4	-	1	1	1
Flindersia dissosperma	s	-	2	-	-	-
Geijera parviflora	s	8	7	-	-	-
Geijera salicifolia	s (rf)	8	1	1	-	-
Murraya ovatifoliolata	s (rf)	4	-	-	-	1
Phebalium glandulosum subsp. *glandulosum*	s	12	-	1	-	3
Zieria aspalathoides	s	7	-	-	-	2
Zieria cytisoides	s	3	-	-	-	2
Santalaceae						
Exocarpos latifolius	s	3	1	1	-	-
Santalum lanceolatum	s	5	5	-	-	-
Sapindaceae						
Alectryon connatus	t (rf)	21	2	1	-	1
Alectryon diversifolius	s	4	6	-	-	-
Alectryon oleifolius	s	1	7	-	-	-
Atalaya hemiglauca	t	7	17	-	-	-
Cupaniopsis anacardioides	t (rf)	13	1	-	1	1
Dodonaea filifolia	s	10	-	-	-	1
Dodonaea lanceolata var. *subsessilifolia*	s	14	-	-	-	-
Dodonaea stenophylla	s	3	-	-	-	2
Dodonaea viscosa subsp. *spatulata*	s	13	8	1	-	-
Elattostachys xylocarpa	t (rf)	1	-	-	1	-
Sapotaceae						
Pouteria cotinifolia var. *pubescens*	s (rf)	4	-	1	1	-
Scrophulariaceae						
Stemodia glabella	f	2	-	1	-	1
Solanaceae						
Datura leichhardtii	f	-	1	-	-	-
Nicotiana forsteri	f	2	-	-	-	1

	Life form	n Peaks	n Context	Fensham & Holman	Fensham's Dry RF	HERBRECS
Solanum ellipticum	f	19	2	1	-	1
Solanum esuriale	f	1	-	-	-	-
**Solanum lycopersicum*	f	1				
Solanum opacum	f	1	-	-	-	1
Solanum parvifolium	f	1	1	-	-	-
**Solanum seaforthianum*	f	-	1	-	-	1
Stackhousiaceae						
Stackhousia intermedia	f	1	-	-	-	-
Sterculiaceae						
Brachychiton australis	t	25	4	1	1	1
Brachychiton populneus	t	6	1	1	-	-
Brachychiton rupestris	t	4	3	1	1	-
Keraudrenia lanceolata	s	1	-	-	-	-
Melhania oblongifolia	f	12	15	-	-	-
Seringia corollata	s	3	-	-	-	-
Waltheria indica	f	9	6	-	-	-
Tiliaceae						
Corchorus trilocularis	f	3	6	-	-	-
Grewia latifolia	s	15	11	1	-	1
Ulmaceae						
Celtis paniculata	t (rf)	8	-	-	1	-
Trema tomentosa	s	16	-	-	-	-
Urticaceae						
Dendrocnide photinophylla	t (rf)	1	-	-	1	-
Pipturus argenteus	s (rf)	1	-	-	1	-
Verbenaceae						
Verbena macrostachya	f	1	-	-	-	-
Violaceae						
Hybanthus enneaspermus	f	4	4	-	-	1
Hybanthus stellarioides	f	2	-	1	-	1
Vitaceae						
Cayratia clematidea	v	9	-	1	-	-
Cissus oblonga	v (rf)	9	-	1	1	1
Cissus opaca	v	13	1	1	1	1
Cissus reniformis	v (rf)	2	-	-	-	-
Xanthorrhoeaceae						
Xanthorrhoea johnsonii	s	14	-	-	-	-
Zygophyllaceae						
Tribulus micrococcus	f	1	2	-	-	-

	Life form	n Peaks	n Context	Fensham & Holman	Fensham's Dry RF	HERBRECS
Pteridophytes						
Adiantaceae						
Adiantum hispidulum	f	4	-	-	1	1
Cheilanthes distans	f	17	-	1	1	1
Cheilanthes sieberi and/or *Cheilanthes nudiuscula*	f	25	-	1	-	1
Doryopteris concolor	f	1	-	1	-	-
Isoetaceae						
Isoetes muelleri	f	2	-	1	-	1
Ophioglossaceae						
Ophioglossum gramineum	f	1	-	1	-	-
Ophioglossum lusitanicum	f	1	-	-	-	-
Polypodiaceae						
Platycerium veitchii	f	3	-	-	1	-
Pyrrosia rupestris	f (rf)	2	-	-	1	1
Bryophytes						
Ptychomitriaceae						
Ptychomitrium australe	f	2	-	-	-	2

Herbicide impacts on exotic grasses and a population of the critically endangered herb *Calystegia affinis* (Convolvulaceae) on Lord Howe Island

Ian Hutton[1], *Robert Coenraads*[2], *Tony D. Auld*[3*], *Andrew J. Denham*[3], *M. K. J. Ooi*[3] *and Dianne Brown*[4]

[1]P.O. Box 157, Lord Howe Island, NSW 2898, AUSTRALIA. [2]Triglana Rd., Frenchs Forest, NSW AUSTRALIA.
[3]Climate Change Science, NSW Dept of Environment & Climate Change, P.O. Box 1967, Hurstville, NSW 2220, AUSTRALIA.
[4] Biodiversity Conservation Section, North East Branch, NSW Dept of Environment & Climate Change,
Locked Bag 914 Coffs Harbour NSW 2450 AUSTRALIA.
*Corresponding author email: tony.auld@environment.nsw.gov.au

Abstract: Introduced perennial grasses are capable of altering the habitat of native species, causing reductions in population size and vigour, and potentially affecting life-history processes such as survival, pollination and seedling recruitment. We examined the utility of herbicide treatment on two exotic grasses, *Pennisetum clandestinum* (Kikuyu) and *Stenotaphrum secundatum* (Buffalo grass) to restore the habitat of *Calystegia affinis*, a critically endangered species endemic to Lord Howe and Norfolk Islands. Using two herbicides, Asset (designed to affect only grasses) and Glyphosate (a general herbicide), we compared effectiveness in reducing grass cover on a population of *Calystegia affinis*. We protected *Calystegia* plants from the herbicides by ensuring their leaves were covered by plastic bags during herbicide application. Both herbicides were similarly effective in reducing grass cover after four weeks and had no noticeable adverse affect on *Calystegia* (suggesting the plastic bag protection was effective). After 26 weeks, Glyphosate was more effective in maintaining a reduced grass cover. Plots treated with either herbicide had a greater relative increase in abundance of *Calystegia* stems compared to untreated controls. The Glyphosate treatment resulted in the greatest relative increase in stem abundance, but this was not significantly greater than in the Asset treatment. We consider that spraying with Glyphosate treatment, with follow-up monitoring and spot-spraying, will assist the recovery of the *Calystegia affinis* population. Ultimately, the maintenance of a weed-free zone at the forest edge will provide suitable habitat for additional recruitment of this and other native species.

***Cunninghamia* (2008) 10 (4): 539–545**

Introduction

Weeds are recognised as a significant threat in many plant communities around the world. In the past few centuries, humans have had a propensity to introduce plants from one country or area to another. Without predators and a lack of competition to keep them in check, introduced plants may flourish and their spread can become a key threat to local biodiversity (Vitousek & Walker 1989; Adair 1995; Mack & D'Antonio 1998; Hoffman *et al.* 2004; Jackson 2005; Williams *et al.* 2005). In Australia, at least 57 nationally-listed endangered species have been identified as being at risk from weeds (Leigh & Briggs 1992). In New South Wales (NSW), over 300 threatened native plant species are considered at risk from exotic plants (Coutts-Smith & Downey 2006). Competition from weeds is therefore a significant factor increasing the risk of extinction faced by threatened species, as well as contributing to their continued decline.

Environmental weeds posing a significant threat in Australia include a range of life forms (Thorpe & Lynch 2000), and in NSW, several exotic grasses have been recognised as a threat to native plant communities (NSW Scientific Committee Determination 2003). Many other grass species, introduced for use in pastures or restoration projects, have escaped from cultivation and become weedy, particularly in coastal and island habitats. One such species is Kikuyu grass (*Pennisetum clandestinum*), a South African native planted in many countries as a pasture grass. Once established, it can spread vigorously and can tolerate a wide range of climatic zones from temperate to subtropical (Holm *et al.* 1977). Another grass species, St. Augustine or Buffalo grass (*Stenotaphrum secundatum*), native to coastal areas of North America, can similarly thrive in temperate and subtropical areas of the world (Gillham 1960; Campos *et al.* 2004, US Forest Service, Pacific Island Ecosystems at Risk (PIER) – accessed November 2007).

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Lord Howe Island (lat 31° 35'S; long 159° 05'E) is a remote subtropical island approximately 500 km off the coast of NSW. Of over 100 endemic plant species on the island (Green 1994), eight are currently listed as endangered under the NSW *Threatened Species Conservation Act* (1995) and two as critically endangered on the Federal *Environment Protection and Biodiversity Conservation Act* (1999). Several of these threatened plants are at risk from competition from Kikuyu and Buffalo grass. Kikuyu was introduced to Lord Howe Island as a pasture grass about 1900 (Pickard 1984) while Buffalo was introduced in the1940s. Both species have thrived in the subtropical maritime climate. Kikuyu and Buffalo grass now cover much of the cleared lowland areas of the Island (Pickard 1984; I. Hutton pers obs.). At the boundary of pastures and the forest edge, these grasses creep into the forest understorey and smother seedlings of native species, preventing recruitment of native forest species. Introduced grasses may also compete with native plants for water and nutrients, hindering the growth, fecundity and establishment of native species (Gillham 1960; Orr *et al.* 2005; Denslow *et al.* 2006; Minchinton *et al.* 2006).

The impact of weeds on a native species will be dependent on the distribution, abundance and life history of the plant. Many threatened species exist only in very low numbers, or in a restricted area, or both. Due to the small size of habitat and range of such threatened species, introduced plant species may have detrimental impacts on their survival. Of particular concern on Lord Howe Island is the Critically Endangered (*EPBC Act* 1999) twiner *Calystegia affinis* Endl. (family Convolvulaceae). *Calystegia affinis* is endemic to Lord Howe and Norfolk Islands (about 900 km northeast). Until recently *Calystegia affinis* was only known on Lord Howe Island from a 1937 collection (J.D.McComish 77A Kew, NSW), and Rodd and Pickard (1983) presumed the plant to be locally extinct. However, a specimen was collected in 1985 at the western end of the area known as Old Settlement. Surveys in 1999 verified the location of the species, but did not find any additional plants at the forest edge around the perimeter of Old Settlement (Hutton & Telford 1999). Subsequent surveys for rare plants (in 2001 and 2002) located another three plants in remote mountain areas at around 500m altitude – one on Mount Lidgbird and two on Mount Gower (Hutton 2001, 2004).

Species from the genus *Calystegia* (*Calystegia* has about 25 species in the tropics and subtropics) have been reported as being clonal, with reproduction often largely by vegetative means (Ushimaru & Kikuzawa 1999; Arafeh & Kadereit 2006) and have extensive, thin, underground rhizomes that produce many leafy stems above ground (Wolf *et al.* 2000). It is likely that *Calystegia affinis* at Old Settlement is also clonal, and the hundreds of stems appearing through the Kikuyu grass may all be one plant, connected by stems and underground rhizomes throughout the grass. Some plants that reproduce clonally can live for decades or centuries (Laberge *et al.* 2000) and the *Calystegia affinis* population at Old Settlement has been there at least since 1985, and is probably the same plant collected in 1937.

The dense cover of Kikuyu and Buffalo grass at Old Settlement is considered likely to be having an impact on the recruitment and persistence of the *Calystegia affinis* (NSW Scientific Committee 2002) and control of exotic grasses in *Calystegia affinis* habitat is an action in the Lord Howe Island Biodiversity Management Plan (DECC 2007). The aim of this study was to trial herbicide treatment at the Old Settlement site, to assess the suitability of herbicides for broader *Calystegia affinis* habitat restoration and to examine the impact of reduced grass competition on the *Calystegia* population. We compared the effectiveness of two herbicides, Nufarm Asset Herbicide (active ingredient haloxyfop) and Glyphosate on stem dieback of the introduced Kikuyu and Buffalo grass, and examined the impact of these herbicides on the survival of existing stems and the emergence of new stems of *Calystegia affinis*.

Methods

Study site and species

The study site is a south-east facing lower slope of Dawson's Ridge, above the Old Settlement flats, just inside the Permanent Park Preserve fenceline (Fig. 1). The soil is basalt-derived loam containing small scattered basalt rock. The adjacent forest is closed rainforest dominated by *Drypetes deplanchei* and *Cryptocarya triplinervis* (Pickard 1983). At the site *Calystegia affinis* is intermingled with dense growth of Kikuyu and Buffalo grass to 50 cm tall. Where the forest canopy is dense and shades the ground up-slope, both grasses and *Calystegia* are absent, but in some areas where tree cover is less dense, native grasses and *Calystegia* occur. Here occasional *Calystegia* stems twine around small stems of other species up to 60 cm above ground level; otherwise *Calystegia* is strictly decumbent. Remnant native species occurring with *Calystegia affinis* include *Parsonsia howeanum, Rapanea platystigma, Cryptocarya triplinervis, Leucopogon parviflorus, Smilax australis, Commelina cyanea, Lobelia sp., Carex brunnea* and *Dodonaea viscosa.*

Initial plant density

To estimate the *Calystegia affinis* density we used 24, 1m x 1m random quadrats recording (on 31/10/2006) the number of *Calystegia* stems in each quadrat emerging through the grass cover.

Herbicide treatments

It was considered that if any habitat restoration were to take place, the best areas would be adjacent to the native forest, rather than in the middle of the introduced pasture grasses. Eight 5m x 5m quadrats dominated by exotic grasses were selected at the boundary of the forest and pasture (Fig. 1).

All quadrats were permanently marked with hardwood stakes and individually numbered with aluminium tags. GPS readings were recorded for the southwest corner of each quadrat. Within each quadrat the number of *Calystegia affinis* stems was recorded.

Herbicide spray was applied to half the quadrats on 1/11/2006. A low dosage (1:200) Glyphosate-based herbicide was applied to two quadrats, and the grass-specific herbicide Asset (at a dosage rate of 1:200) was applied to two quadrats. A 1:200 Glyphosate treatment is often used in vegetation restoration programs as this dosage kills weeds but does not affect native plant species. No treatment was applied to the remaining four quadrats.

To make identification of individual *Calystegia affinis* stems easier, all individual stems within the quadrat were marked with plastic flagging tape prior to herbicide treatment. To avoid herbicide damage to *Calystegia*, individual plastic sandwich bags were carefully placed over any leaves and stems to minimise the probability of herbicide uptake (Buchanan 1995).

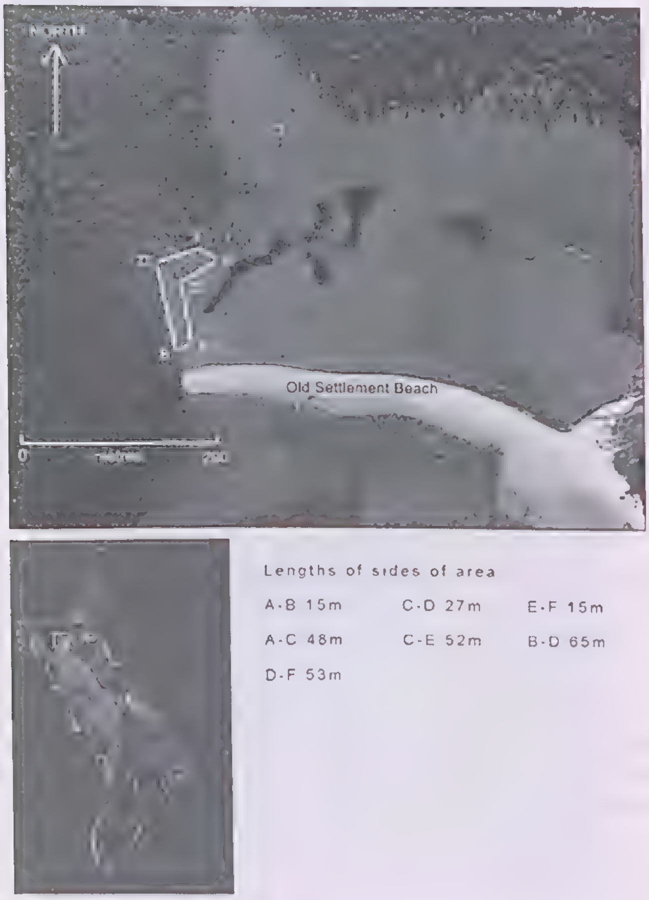


Fig. 1. Location of *Calystegia affinis* study site on Lord Howe Island.

At four weeks and 26 weeks after treatment, the cover of all species in the quadrats was assessed. For grass cover, this included a separate estimate of both living and dead material. All *Calystegia* stems that had died, and any new ones that had grown, were counted.

Data Analysis

At four week (short-term) and 26 weeks (mid-term), we compared the three treatments (Glyphosate, Asset and no application of herbicide) in terms of the reduction in cover of live exotic grass using a 1 Factor ANOVA. At four weeks only, we examined the proportion of stems of *Calystegia affinis* that had died since the initiation of the study with a 1 Factor ANOVA. At 26 weeks, we also examined proportional change in the number of stems of *Calystegia* using a 1 Factor ANOVA. For all analyses, Cochran's Test was used to test for homogeneity of variances. Where heterogeneous variances were detected, the data were arcsine transformed (Underwood 1981). For the 26 week comparison of proportion of exotic grass killed, the data were heterogeneous even after arcsine transformations and the ANOVAs were performed on the raw data with a conservative approach to rejecting the null hypothesis in order to avoid Type 1 errors (i.e. the null hypothesis was not rejected unless the probability of the F-ratio in the ANOVA was <0.01). Where ANOVAs were significant, individual means were compared using Student-Newman-Keuls tests (Zar 1984).

Results

The density of *Calystegia affinis* at 31/10/2006 in the 1m x 1m quadrats ranged from 0 to 5 stems m^{-2} (mean 1 ± 0.3 stems m^{-2}). As the study area covers some 2313 m^2, we estimate that it contained some 2313 (± 648) *Calystegia affinis* stems. Across the 25 m^2 treatment plots, the density of *Calystegia affinis* ranged from 0.2 to 4.4 stems m^{-2}. The absolute number of stems per 25 m^2 plots was also very variable (ranging from 5 to 19 in six of the plots, with two plots with large numbers (98 and 110).

We identified 15 plant species in the study area– five introduced weeds (*Pennisetum clandestinum*, *Stenotaphrum secundatum*, *Paspalum* sp., *Lilium formosanum*, *Vicia sativa*), and 10 native species – twiners and climbers (*Calystegia affinis*, *Commelina cyanea*, *Parsonsia howeanum*, *Smilax australis*), herbs (*Lobelia* sp., *Carex brunnea*), small shrubs (*Dodonaea viscosa*, *Leucopogon parviflorus*) and occasional stunted individuals of the tree species (*Cryptocarya triplinervis* and *Rapanea platystigma*).

On many leaves of *Calystegia affinis* both within study quadrats and across the whole area, there was evidence of extensive leaf damage, caused by the beetle *Arsipoda parvula*. New leaves appeared to be free of this damage, and older leaves more affected. The impact of this beetle on *Calystegia affinis* is unknown. This beetle is also found in

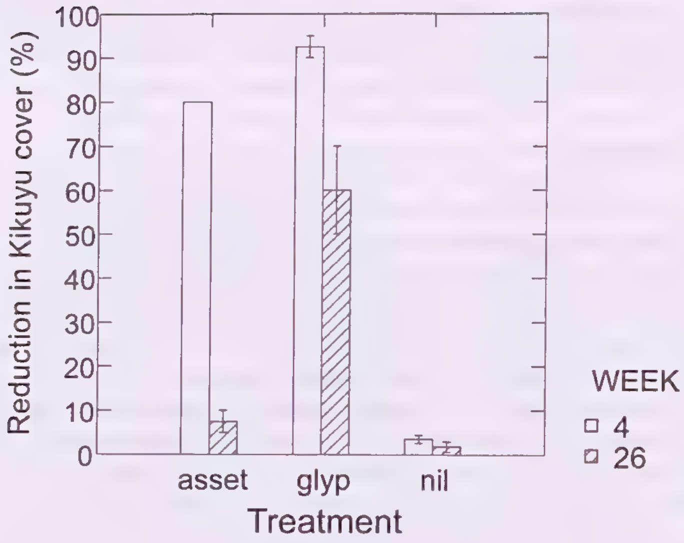


Fig. 2. Mean reduction in exotic grass cover (± 1 standard error) after herbicide treatment. Four weeks after treatment (open bars); 26 weeks after treatment (filled bars).

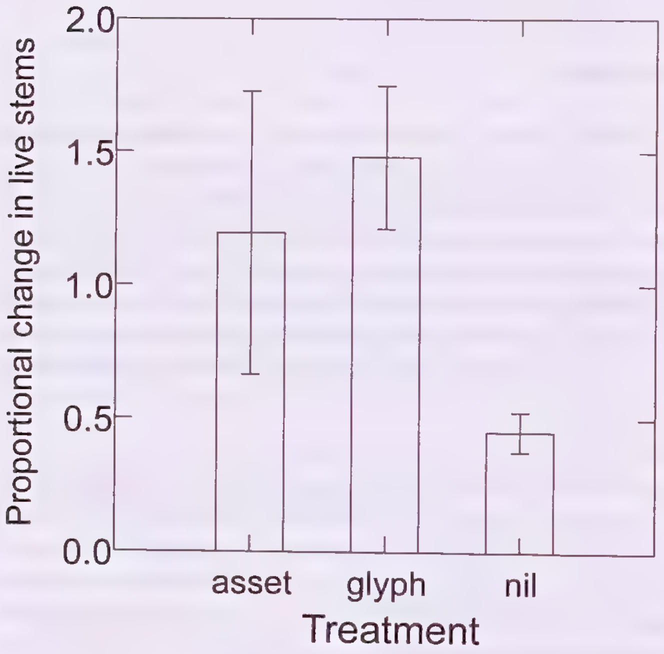


Fig. 3. Proportional change in the number of living stems of *Calystegia affinis* 26 weeks after application of treatments. A value of 1 means no change. Values of less than 1 represent a decline, values of more than 1 an increase. Bars are means ± 1 standard error.

Queensland and is known to graze on other species within the Convolvulaceae family.

At four weeks after the application of the herbicide treatments there was a marked reduction ($P<0.001$) in the cover of live exotic grass in both the Glyphosate and Asset compared to only a very small reduction in the control plots (Figs. 2,4). At 26 weeks, there was still a marked reduction for the Glyphosate treatment ($P<0.001$), while the Asset and controls were comparable (Figs. 2,4).

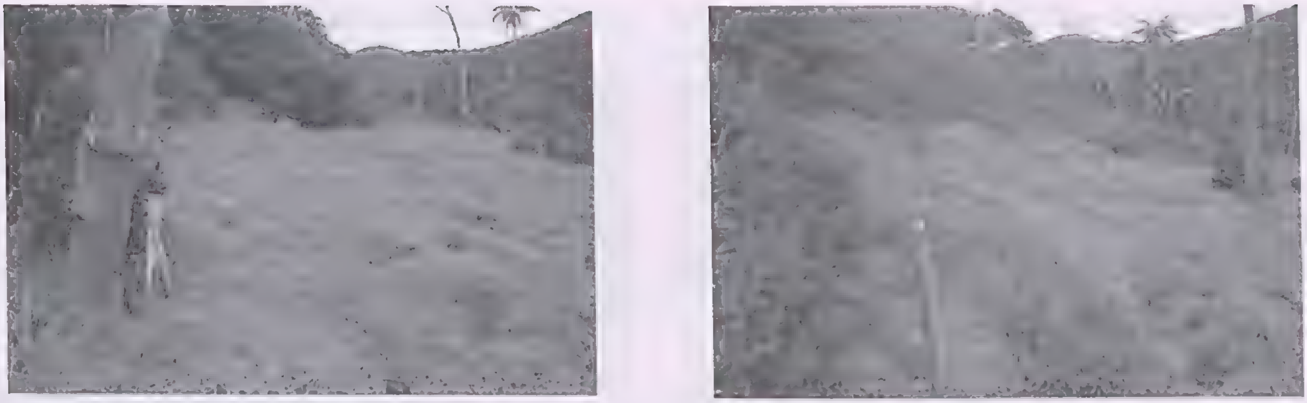
The initial impact of spraying on *Calystegia affinis* stems at four weeks was different across the herbicide treatments ($P = 0.024$). There was slightly less stem death in the Asset treatment than the control, while Glyphosate was not different from either. Essentially, the experimental bagging of *Calystegia* leaves minimised any negative effect of the herbicides on living stems. There was some initial production of new stems in the first four weeks after herbicide treatment, but all stems died back over summer between the four and 26 week sampling. At 26 weeks, there was no significant difference across all treatments ($P = 0.058$) in live stems as a proportion of the original number of stems observed. There was however, a trend for a greater proportion of new stems in both herbicide treatments than in the control (Fig. 3).

Discussion

Targeted herbicide spraying had the desired effect of reducing exotic grass cover while doing minimal damage to *Calystegia affinis* plants (Fig. 4). This contrasts with weed control regeneration attempts in other habitats where non-selective herbicides may significantly impact upon native species (Brown *et al.* 2002; Matarczyk *et al.* 2002; but see Brown 2006 for success with a selective herbicide). The protection of individual *Calystegia affinis* stems using plastic bags while herbicide treatment was carried out was effective, and minimal loss of *Calystegia* was caused by herbicide spraying. Though some *Calystegia* stems present at the start of the trials (marked with ribbon) died, new ones grew within four weeks, in both the treated and the control quadrats.

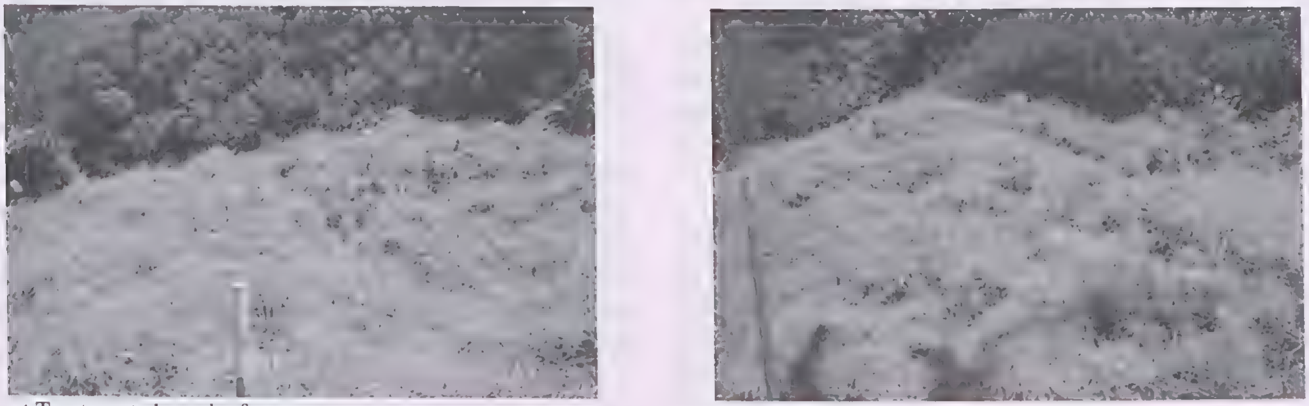
Both herbicides were effective in reducing the cover of exotic grasses after four weeks. However, over the longer term (26 weeks) there was more regrowth of exotic grass cover in the Asset treatment than in the Glyphosate treatment (Figs. 2,4). Thus, in this situation, the Glyphosate treatment was ultimately more effective in reducing exotic grass cover than the grass-specific Asset herbicide. Longer periods of reduced exotic grass cover should allow more new *Calystegia affinis* stems to be produced and/or fewer stems dying from being overgrown by grass.

In this study, there was only one herbicide treatment spraying, and after 26 weeks considerable introduced grass regrowth had taken place. Further treatment with the Glyphosate herbicide could be beneficial to prevent more grass regrowth,



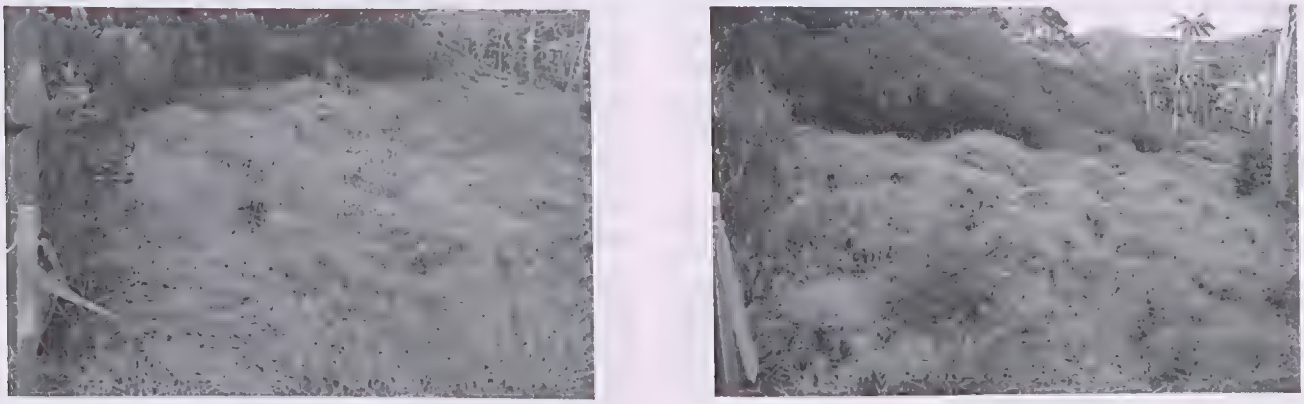
Asset Treatment: Pre-application Nov 2006

Glyphosate treatment: Pre-application Nov 2006



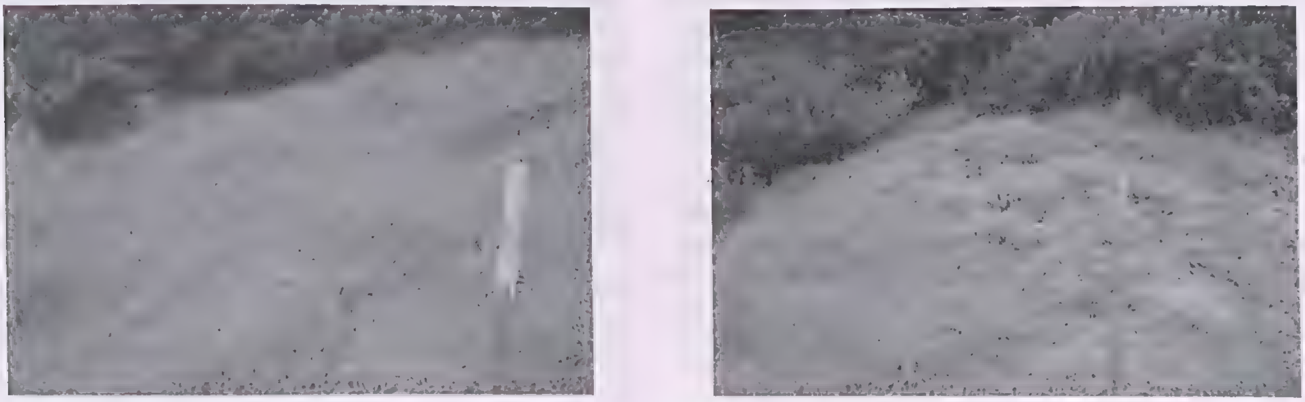
Asset Treatment: 1 week after treatment

Glyphosate treatment: 1 week after treatment



Asset Treatment: 4 weeks after treatment

Glyphosate treatment: 4 weeks after treatment



Asset Treatment: 26 weeks after treatment

Glyphosate treatment: 26 weeks after treatment

Fig. 4. Photographic comparison of one plot each of Asset and Glyphosate treatments from pre-treatment (November 2006) to 1 week, 4 weeks and 26 weeks post-treatment. There was continuous grass cover in the control plots.

provided *Calystegia affinis* plants are protected during any herbicide application. Other alternatives to reduce grass regrowth may be less practical, eg mowing (it would be hard to ensure stems of *Calystegia affinis* were not destroyed), or hand-weeding (too labour intensive for the size of the area to be treated).

All stems of *Calystegia affinis* that were present at the start of the trial (and marked with plastic ribbons) had died after 26 weeks, regardless of herbicide treatment. This may be a feature of the life history of this species. However, the summer from December 2006 to March 2007 was extremely dry for Lord Howe Island. Rainfall figures were December 62 mm (average 106 mm), January 18 mm (average 127 mm), and February 37 mm (average 122 mm) (Bureau of Meteorology LHI). This dry period may have been the cause of the death of these stems. Competition from introduced grasses and the browsing by beetles may have contributed. All of the new leaves that were present after 26 weeks were very healthy in appearance, and bright green, with no insect damage.

Irrespective of herbicide treatment, more *Calystegia affinis* stems were present after 26 weeks than we observed after 0 or 4 weeks; but the quadrats treated with herbicide had a much greater increase in new stems (Fig. 3). This difference was not significant due in part to the small sample size and variation in the data. If the observed trend is real, then treatment of introduced Kikuyu and Buffalo grass with herbicide does benefit the overall vigour of the threatened *Calystegia affinis* as indicated by the increased number of new stems after herbicide treatment compared to the untreated control plots. At any rate, the observed reduction in live exotic grass cover at 26 weeks under the Glyphosate treatment is also likely to enhance growth and survival of *Calystegia* stems.

We noted that in the area around two of the quadrats, there were many small native plants that were stunted and being smothered by Kikuyu and Buffalo grasses. We believe that if these plants are freed from the grasses they will slowly recover normal growth resulting in a semi-shaded area that may provide suitable habitat for *Calystegia affinis*. In previous surveys (Hutton & Telford 1999; Hutton 2001, 2004), and while carrying out this trial, it was observed that *Calystegia* does not grow into the heavily shaded forest canopy edge, but where it is fully exposed, where it faces competition from introduced Kikuyu and Buffalo grass. Consequently, there may be a need to maintain open edges to allow *Calystegia* plants to persist at the site.

As the biomass of exotic grasses is removed, other secondary weeds from adjacent pastures are likely to invade (e.g., Scotch thistle, *Onopordum acanthium*, and Vetch, *Vicia sativa*). Treating the introduced grasses with herbicide and leaving the dead grass mat *in situ* will provide mulch to inhibit secondary weeds for some time.

Conclusions and recommendations

Following the results of this study we suggest that the area adjacent to this trial be further treated with Glyphosate to improve the habitat for *Calystegia affinis*. Prior to herbicide treatment, all surviving native shrubs, trees, twiners and grasses should be freed up of Kikuyu and Buffalo grasses by gently pulling the grasses off, using secateurs where necessary. Abundance of all plant species in the restoration area should be recorded. The number of *Calystegia* stems should be recorded and each stem marked with coloured ribbon and protected by placing inside plastic bags just prior to herbicide treatment. The area should then be treated with 1:200 Glyphosate spray, being careful to minimise any herbicide overspray reaching native plants. Wherever native plants occur, a protective shield (e.g. cardboard or stiff plastic) should be used to shield the plant while spraying adjacent grass. Twenty-four hours after treatment all plastic bags should be removed from *Calystegia* plants.

At two, four and six months after herbicide treatment the site should be checked for any live exotic grasses and if necessary treated with 1:200 Glyphosate herbicide using a hand-held one litre spray pack. The number and condition of all *Calystegia* stems, and other native plants should be recorded.

The adjacent forest area has a groundcover of native *Carex* species; these also occur in the disturbed site. These species are common groundcovers in equivalent habitats elsewhere on Lord Howe and it may be beneficial to propagate them at the Island nursery, for planting in the restoration site (when the dead kikuyu has broken down), to provide groundcover that will inhibit weed invasion. Plots established during this trial may be used for ongoing monitoring, including population numbers, recruitment and life history observations.

Green (1994) has suggested that Lord Howe and Norfolk Island populations of *Calystegia affinis* may perhaps be separate subspecies, so a DNA comparison of the Lord Howe and Norfolk Island populations to determine if they are distinct species or subspecies would be a valuable addition to our understanding of this rare species (Wolf *et al.* 2000, Arafeh & Kadereit 2006). Observations on flowering material indicate the flower corolla of the Lord Howe Island plants are approximately 3.5 cm long compared with 2.5 cm long on Norfolk Island plants (Peter Green pers. comm.).

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Germination responses of a dry sclerophyll forest soil-stored seedbank to fire related cues

Penman, T.D[1, 3, 4], *Binns, D.L.*[2], *Allen, R.M.*[1], *Shiels, R.J.*[1] *and Plummer, S.H.*[3]

[1] Forest Science Centre, Dept of Primary Industries, PO Box 100, Beecroft, NSW 2119 AUSTRALIA.
[2] Forests NSW, PO Box J19, Coffs Harbour Jetty, NSW 2450 AUSTRALIA.
[3] Bushfire Co-operative Research Centre, 5/340 Albert Street, East Melbourne Vic 3002, AUSTRALIA.
[4] Corresponding author: Trent Penman email: trentp@sf.nsw.gov.au

Abstract: Fire is an integral component of many ecosystems worldwide. Many plant species require fire-related cues, primarily heat and smoke, to trigger germination. Despite the importance of this process, the responses of many Australian species to these cues are unknown. Without this knowledge fire management strategies may be developed that are inappropriate for individual species and vegetation communities. In this study we examined the responses of a dry sclerophyll forest seed bank to heat and smoke germination cues. Analysis was possible for 48 taxa within the soil seedbank with 34 of these showing a response to one or both of the germination cues. 10 species responded to the heat treatment, 11 species responded to the smoke treatment and 13 species responded to both the heat and smoke treatments. Germination cues acted independently for all species considered. Results in this study were consistent with published reports for most species, although some differences were seen at the species and genus level. The study highlights the importance of fire-related cues in enhancing germination of a large proportion of the species occurring in dry sclerophyll forests.

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Introduction

Many plant species accumulate a soil-stored seedbank, an important mechanism of survival for obligate-seeding species particularly in fire prone environments (Gill 1981). One important factor which influences distribution and abundance of plant species in relation to fire is the response of this seedbank (Keith 1996). The well-known pulse of post-fire germination is at least partly due to seeds being released from dormancy by fire-related cues (Noble & Slatyer 1981).

Heat and smoke are considered the primary fire related cues for triggering germination. Heat has been shown to stimulate germination in a wide range of species, from a number of families including Fabaceae (Auld & O'Connell 1991; Enright *et al.* 1997), Convolvulaceae (Read *et al.* 2000) and Cyperaceae (Thomas *et al.* 2003). Heating fractures the seed coat enhancing germination, particularly in hard-seeded species. The optimum range of temperatures for germination varies between species (e.g., Kenny 2000; Morris 2000; Read *et al.* 2000; Hill & French 2003), with short term exposures (of only a few minutes) to high temperatures (>100°C) resulting in seed mortality in some species (Keeley & Keeley 1987; Auld & O'Connell 1991). The role of smoke or smoke compounds in triggering germination has received increasing attention in recent years (Clarke *et al.* 2000). Smoke has been found to trigger germination in native species from South Africa (e.g., Brown *et al.* 1994), North America (e.g., Keeley & Fotheringham 1997), Europe (e.g., Rivas *et al.* 2006) and Australia (e.g., Roche *et al.* 1997a; Read & Bellairs 1999; Clarke *et al.* 2000; Enright & Kintrup 2001). For many species the combined application of smoke and heat significantly increases germination (Keith 1997; Kenny 2000 ; Tieu *et al.* 2001). These changes can be independent and additive, synergistic or unitive (Thomas *et al.* 2003).

Germination responses of species within some native vegetation communities have been well studied, though many remain poorly studied. Heath and woodland communities have received the most attention (Enright *et al.* 1997; Benwell 1998; Enright & Kintrup 2001; Wills & Read 2002; Wills & Read 2007) particularly in the Sydney basin area in eastern Australia (Auld & O'Connell 1991; Kenny 2000; Hill & French 2003; Thomas *et al.* 2003). Similarly heath and forest communities in south-western Australia have received considerable attention (e.g., Bell *et al.* 1987; Enright & Lamont 1989; Meney *et al.* 1994; Dixon *et al.* 1995; Roche *et al.* 1997b; Smith *et al.* 1999; Tieu *et al.* 2001; Baker *et al.* 2005). Fewer studies have been conducted in other vegetation communities such as savannas (Williams *et al.* 2005) and dry forests (Wang 1997; Read *et al.* 2000).

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Understanding how individual species respond to fire-derived cues will result in improved predictions regarding the impacts of fire management practices on individual species, hence communities. In this paper, we tested the effect of a single heat treatment (80°C), a smoke treatment, and an interaction of the two, on a soil seedbank from a dry sclerophyll forest in south-eastern New South Wales (NSW).

Materials and Methods

Soil samples were collected from the Eden Burning Study Area (EBSA) in south-eastern NSW, Australia (lat 37° 14′S, long 149° 38′E). The EBSA is a 1080 ha area of southeast dry sclerophyll forests in Yambulla State Forest, managed by Forests NSW. Dominant canopy species in the site are *Eucalyptus consideniana, Eucalyptus sieberi, Eucalyptus agglomerata, Eucalyptus globoidea, Eucalyptus muellerana and Eucalyptus cypellocarpa*. Established in 1986, the EBSA was designed to examine the effects of timber harvesting and repeated prescribed burning on a range of ecological attributes (for more details see Binns & Bridges (2003) and Penman *et al.* (2008)).

In April 2006, soil was collected from 213 permanently marked understorey vegetation plots, at a distance of 6 m from the plot centre (routine vegetation measurements are taken within a 5.64 m radius and we did not wish to interfere with these). Nine samples were taken from each plot starting from a random bearing from the plot centre and then at 40° intervals or approximately 4.2m arcs. Each sample was a taken from the top 10 cm of the soil profile using an auger (8 cm diameter), resulting in a total of approximately 3.5 kg of soil per plot. During collection, soil samples were combined in a breathable calico bag and mixed together. Soil samples were air-dried, to prevent mould-damage to the soil-stored seeds, and to ensure the subsequent heat treatment (see below) was dry heat and not wet heat.

In the laboratory, the combined soil samples from each plot were mixed thoroughly a second time then divided into four equal sub-samples. Sub-samples were then randomly assigned to one of four germination treatments – Control, Heat, Smoke, and combined Heat plus Smoke. The heat treatment involved placing the soil in aluminium trays which were then placed in a dry oven at 80°C for one hour. For the Smoke and Heat plus Smoke treatments, samples were placed in a semi-sealed (3m x 3m) room with a smoke generator in one corner which was run continuously for two hours fuelled by native vegetation. The samples were then left in the room for another hour while the smoke settled. Temperatures in the smoking room were monitored throughout the smoking process and did not rise by more than 5°C above ambient temperatures (20–25°C).

All treated and control samples were then placed in seedling trays (350 x 295 x 50 mm), which were placed randomly in a glasshouse. For each plot, samples were placed into two seedling trays, each divided into two discrete sections using an aluminium divider. The first tray held the control and heat treatments and the second the smoke and the combined heat plus smoke treatments. For the first five days following the smoking treatment, all trays were lightly watered for five minutes once a day. Following this period, samples were watered using misting spray for five minutes every 12 hours. The glasshouse was kept at ambient temperature, except during the peak of summer where an air-conditioner was used to keep temperatures below 35° C. Germinating seedlings were identified at approximately two monthly intervals from June 2006 through to June 2007. Nomenclature used was that accepted by the National Herbarium of New South Wales, Sydney (Royal Botanic Gardens & Domain Trust 2007). After being identified, each specimen was removed from the tray to prevent double counting.

We used a general linear model to determine the influence of each germination cue in which we included only the plots on which each species germinated. Only species recorded in ten or more sub-samples (out of the 213 plots with four sub-samples from each) were considered in the analysis. For each plot, we calculated the proportion of seedlings, of a given species, that germinated in each of the four treatments. We then compared these proportions using a two factor general linear model with heat and smoke as the two factors. Scores were weighted using the square root of the number of seedlings germinating from the plot. A square root transformation was used to ensure plots with extremely large numbers of seedlings did not have undue influence on the analysis. Tukey's HSD test was used for post-hoc comparisons where significant interactions were recorded (Quinn & Keough 2002). All analyses were conducted in the R-package v 2.5.0 (R-Development Core Team 2007).

Results

A total of 8510 seedlings germinated during the 12 month study, comprising 103 species, with a further 6 taxa only identified to genus level or higher (Appendix 1). There were 42 shrub and sub-shrub species (hereafter termed shrubs), 62 herbs, 2 vines, 1 tree species (*Allocasurina littoralis*) and an aggregate group of eucalypt taxa (species of *Eucalyptus* and *Corymbia*). The eucalypts were not identified to species level and are not considered further in this paper. Several species of orchids also appeared in the trays, but these were all resprouts from tubers and not counted as germinants. The most common taxa occurring in the seedbank were *Epacris impressa* (1165 seedlings at 161 plots), *Gonocarpus teucrioides* (1055 seedlings) and *Wahlenbergia spp.* (909 seedlings). These three species made up 37% of the total germinants. Three introduced species were recorded amongst the germinants albeit in low numbers – *Centaurium erythraea* (21 seedlings), *Cirsium vulgare* (1 seedling) and *Conyza* sp. (1 seedling).

Table 1: Summary of the germination response to Heat and Smoke treatments for all species with more than 10 seedlings. Values presented are for parameter estimates in the model with positive estimates indicating a positive response to the germination cue and negative estimates indicating a negative response, i.e. reduced germination in the treatment compared to the controls. * indicates significance at the 0.05 level, ** significance at the 0.01 level, * significance at the 0.001 level and ^{m} indicates a marginally significant result with p values between 0.05 and 0.1.**

a) Herb species

Family	Species	Heat	Smoke	Interaction	Num. of germinants
Apiaceae	*Hydrocotyle* spp.	0.078	0.175	-0.232	45
Asteraceae	*Chrysocephalum baxteri*	-0.025 *	0.340 ***	-0.170 ^{m}	85
	Euchiton gymnocephalus	0.046	0.042	-0.177 *	218
	Euchiton sphaericus	0.325	0.024	-0.201	29
	Lagenifera stipitata	0.11	0.184 *	0.059	27
Campanulaceae	*Wahlenbergia* spp.	0.039	0.072 ^{m}	-0.073 ^{m}	909
Centrolepidaceae	*Centrolepis strigosa*	0.250 *	0.098	-0.019	181
Clusiaceae	*Hypericum spp.*	0.011	-0.004	0.02	171
Convolvulaceae	*Dichondra repens*	0.492 *	0.001	0.017	16
Cyperaceae	*Caustis flexuosa*	0.001	0.325 **	0.06	17
	Gahnia clarkei	0.207	-0.105	-0.073	21
	Gahnia radula	0.076	-0.043	0.117	38
	Lepidosperma laterale	0.328 ***	0.210 ^{m}	-0.181	56
	Schoenus apogon	0.167 **	0.067	-0.059	384
	Schoenus maschalinus	0.122	0.167	-0.174	101
Droseraceae	*Drosera* spp.	-0.009	-0.072	0.245	110
Euphorbiaceae	*Poranthera microphylla*	0.143 ***	0.136 ***	0.039	292
Gentianaceae	*Centaurium erythraea*	0.027	0.095	-0.03	71
Haloragaceae	*Gonocarpus micranthus*	0.123 *	0.009	0.21	66
Iridaceae	*Patersonia* spp.	0.030	0.032	0.009	46
Juncaceae	*Juncus planifolius*	0.035	0.124 **	0.024	150
Oxalidaceae	*Oxalis* spp	0.062	0.123	-0.025	19
Poaceae	*Dichelachne rara*	0.202 *	0.045	-0.065	68
	Microlaena stipoides	0.263 m	0.145	-0.263 ^{m}	52
	Tetrarrhena juncea	0.123	0.184 **	-0.177 *	200
Rubiaceae	*Galium* spp.	0.036	0.083 ^{m}	0.064	68
Selaginellaceae	*Selaginella uliginosa*	0.260	0.257	-0.253	17
Violaceae	*Viola hederacea*	-0.005	0.018	-0.029	187

b) Shrub and sub-shrub species

Family	Species	Heat	Smoke	Interaction	Num. of germinants
Apiaceae	*Platysace lanceolata*	0.149 **	0.244 ***	-0.11	263
	Xanthosia tridentata	-0.035	0.248 ***	0.086	64
Asteraceae	*Cassinia longifolia*	0.107 ^{m}	0.103	-0.003	101
Dilleniaceae	*Hibbertia empetrifolia*	0.212 *	0.146 ^{m}	-0.022	32
Ericaceae (Epacridaceae)	*Epacris impressa*	0.136 ***	0.135 ***	-0.024	1165
	Monotoca scoparia	0.208 **	0.143 ^{m}	-0.021	60
Euphorbiaceae	*Amperea xiphoclada*	0.078	0.383 ***	0.079	25
Fabaceae (Faboideae)	*Aotus ericoides*	0.101 m	0.22 **	0.096	29
	Daviesia buxifolia	0.117 ***	-0.132	0.205	59
Fabaceae (Mimosoideae)	*Acacia longifolia*	0.380 **	0.152	-0.064	15
	Acacia myrtifolia	0.688 ***	-0.047 ***	-0.471 **	25
	Acacia terminalis	0.517 ***	0.000	-0.033	14
Haloragaceae	*Gonocarpus teucrioides*	0.022	0.101 ***	-0.035	1055
Myrtaceae	*Kunzea ambigua*	-0.01	0.083 **	0.021	801
	Kunzea ericoides	-0.225	0.170 ^{m}	0.211	36
	Leptospermum scoparium	0.062	-0.046	-0.125	13
Pittosporaceae	*Billardiera procumbens*	0.144 *	0.224 ***	-0.032	90
Rubiaceae	*Opercularia aspera*	0.086 m	0.256 ***	-0.002	120
	Opercularia varia	0.091 ***	0.194 ***	0.027	498
Tremandraceae	*Tetratheca pilosa*	0.103 *	0.26 ***	0.123	35

Five herbaceous species that had not been previously recorded on the study site (Binns & Bridges 2003) were recorded in the soil seedbank, four in very low numbers – *Deyeuxia parviseta* (10 seedlings), *Lobelia alata* (3 seedlings) and *Luzula* spp. (8 seedlings) and the weed *Cirsium vulgare* (1 seedling). The fifth species, *Schoenus apogon*, with 384 seedlings, occurred in 24 plots (11%).

Forty one obligate seeders (27 shrubs, 13 herbs, 1 vine) that have been identified in the above-ground vegetation in the plots (Binns & Bridges 2003) did not germinate in any of the trays during this study (Appendix 1). Three of these species have canopy stored seedbanks (*Banksia marginata, Hakea eriantha* and *Hakea sericea*) and were unlikely to be present in soil seedbank. The remainder of these species are relatively rare as adults, with 36 of the missing species having been recorded on less than 5% of the plots during the study period, of these 32 have been recorded on less than 2% of the plots. The remaining two species *Pultenaea linophylla* (20 plots) and *Olearia ramulosa* (26 plots) were each recorded from about 10% of the plots.

Analysis of the effect of treatment on germination was conducted for 48 taxa (41 species and 7 identified only to genus) of which 34 responded to one or both of the treatments (Table 1). 18 species (11 shrubs and 7 herbs) had significantly higher germination in the Heat treatment when compared to the unheated Control samples. A further four species (3 shrubs, 1 herbs) had marginally higher germination in the Heat treatment. One herb *Chrysocephalum baxteri* had significantly lower germination in the Heat treatment (p=0.004). Eighteen species had significantly higher germination in the Smoke treatment (12 shrubs, 6 herbs) with 3 shrubs and 3 herbs having marginally higher germination in the Smoke treatment. Of the Smoke responsive species, 10 shrubs and 3 herbs had also shown a significant or marginally significant heat response.

Significant Heat plus Smoke treatment interactions were recorded for six species. Of these, for *Acacia myrtifolia*, germination in the Heat only treatment was significantly higher than all other treatments (p<0.001 for all comparisons). *Chrysocephalum baxteri* recorded a marginal interaction which was due to significantly higher germination in the Smoke only treatment when compared with the Heat only treatment (p<0.001) and the control (p<0.001). For *Tetrarrhena juncea* germination was higher in the Smoke treatment than the control (p=0.009) with no other significant differences recorded. Interactions were recorded for *Euchiton gymnocephalus, Microleana stipoides* and *Wahlenbergia* spp. but post-hoc comparisons found no significant differences between any of the four treatments.

Discussion

The results of this study highlight the importance of fire in promoting germination in dry sclerophyll forest communities. Fire cues increased the rate of germination in 34 of the 48 taxa with sufficient data for analysis. Heat and smoke acted independently for all species, occasionally in an additive manner but never in a synergistic or unitive manner. The mechanisms by which fire related cues, i.e. heat and smoke, trigger germination are relatively well understood (e.g., Bell 1999; Kenny 2000; Thomas *et al.* 2003) and are not discussed further here.

Many of the species responses to fire-related germination cues were consistent with those reported by other studies. Fabaceae are well-known for their germination responses to heating (e.g., Auld & O'Connell 1991; Morrison *et al.* 1992; Bell 1999; Read *et al.* 2000). In this study, all the Fabaceae species, *Acacia longifolia, Acacia myrtifolia, Acacia terminalis, Daviesea buxifolia* and *Aotus ericoides,* responded positively to the Heat treatment. The positive responses of *Epacris impressa* to Smoke and Heat treatments (Enright & Kintrup 2001), *Tetratheca pilosa, Opercularia varia* and *Kunzea ambigua* responses to Smoke treatments, and *Dichondra repens* and *Poranthera microphylla* responses to Heat treatments, were consistent with published data (Roche *et al.* 1997b; Coates 2003; Thomas *et al.* 2003; Read *et al.* 2000; Hill & French 2003 respectively)

A number of species exhibited identical responses to other species within the same genus. To our knowledge responses of these species have not been reported in previous studies. Positive responses to smoke have been reported within *Billardiera* (Dixon *et al.* 1995; Roche *et al.* 1997b), *Hibbertia* (Dixon *et al.* 1995; Roche *et al.* 1997b; Clarke *et al.* 2000, *Platysace* (Roche *et al.* 1997b) and *Xanthosia* (Dixon *et al.* 1995; Roche *et al.* 1997b). *Opercularia* species responded positively and independently to smoke and heat treatments (Read *et al.* 2000; Enright & Kintrup 2001; Hill & French 2003). The lack of responses to both heat and smoke treatments has been reported previously for the *Hydrocotyle* and *Oxalis* species (Hill & French 2003).

Three species in this study did not respond to germination cues that had been reported previously in the literature. *Centrolepis strigosa* has been reported to respond to both smoke and heat (Enright & Kintrup 2001) whereas we found only the Heat treatment increased germination. *Microlaena stipoides* has been reported as having a negative response to smoke treatments (Read & Bellairs 1999) but a positive response to heat and smoke (Clarke *et al.* 2000). In our study, the effect of Heat was marginal for this species with no Smoke response recorded. *Wahlenbergia* spp. responded to our Smoke treatment but not to our Heat treatments, whereas Enright & Kintrup (2001) reported positive responses to both these cues. The lack of response in our study may have been a result of different Heat treatment. Enright & Kintrup (2001) placed soil samples in a 100° C oven for an hour, Clarke *et al.* (2000) placed seeds in an 80° C oven for 15 minutes and our study placed soil samples in an 80° C oven for an hour. Similarly, both Enright & Kintrup (2001) and Clarke *et al.* (2000) applied smoke related compounds through smoked water whereas we used a direct application of smoke from native fuels.

Four species exhibited responses different to published data for their respective genera. *Euchiton involucratus* has been recorded as responding positively to heating treatments (Tang *et al.* 2003), but we found no responses recorded for either *Euchiton* species in this study. *Drosera glanduligera* responded independently to the effects of heat and smoke in a study by Enright & Kintrup (2001). However, neither cue increased the level of germination for the *Drosera* species group in this study. Thomas *et al.* (2003) found *Gahnia sieberiana* increased germination in heat and smoke treatments, but neither *Gahnia* species in this study, *Gahnia radula* and *Gahnia clarkei*, responded to either treatment. These differences are not unexpected as responses to germination cues can vary between species within a genus (Bell 1999).

Heat or smoke increased germination in over 70% of species in this study. For some species, such as species of *Acacia*, there was little or no germination in untreated soil, but the extent of the increase in treated soil was dramatic, consistent with the post-fire recruitment pulse which is often reported from field observations. However, other species responded in both the treated and control samples with only a relatively small increase in response to treatment. In the field, such species may appear to rapidly increase after fire to a greater extent than implied by our results. The difference may be attributed to increased survival of germinants of these species in the post-fire environment due to the removal of competitive effects from other species. Species for which germination is enhanced by fire or smoke may increase in relative abundance over time, if fires occur at intervals less than age to senescence but greater than time to maturity. In contrast, the long-term absence of fire will favour those species which germinate independently of heat or smoke treatments and which can survive and mature in intact vegetation.

The differing responses of species suggest that there is likely to be spatial variation in germination in the post-fire environment. Species only responding to the heat cues will only have increased germination within the burnt area, if sufficient temperatures have been reached. Current data suggests that temperatures used in this study to trigger germination (>80° C) are rarely reached in prescribed burns (e.g., Bradstock & Auld 1995; Penman *et al.* 2006; Penman & Towerton 2008); these species require hotter fires (e.g., medium to high intensity wildfires) to trigger germination. While it might be argued that these temperatures may be achieved on hot days, data suggests that this is only possible in the upper 0.5 cm post-fire (Auld & Bradstock 1996) where successful germination is rarely recorded (Auld & Denham 2006). In contrast, those species that germinate in response to smoke would be expect to exhibit increased germination both within and adjacent to the burnt area (regardless of the soil temperature), as the smoke disperses. To our knowledge, no study has recorded the distance from a fire at which smoke can increase germination in the field situation, although this warrants further attention.

Few species in this study recorded any synergistic effects of heat and smoke, although some additive effects were recorded (cf Thomas *et al.* 2003). Most species responded independently to one of the germination cues tested, although some species (e.g., *Poranthera microphylla* and *Epacris impressa*) responded to both independently. In a field situation, these species are expected to exhibit increased germination across a much larger area than those species responding to only one cue. The greatest germination for these species would be within the burn area, with increased germination still expected in adjacent areas affected only by smoke.

Forty-one obligate seeder species that have been recorded previously in the above-ground vegetation at the EBSA were not recorded in this study. These species occur in only a small proportion of plots at the study site, and may have correspondingly low numbers of soil-stored seed; the limited soil-stored seedbank sampling regime may not have captured them in this study. Alternatively, it is possible that different germination cues are required for some of these species.

This study has contributed to our knowledge of germination responses for a range of dry sclerophyll forest species. For many species we have reported results which are consistent with previous studies, but we have also reported on some previously undocumented species and some for which the response varied from that previously described. Knowledge of germination response can aid in interpreting plant community changes after fire. Combined with knowledge of other plant life history attributes, and information on interactions with other species and the physical environment, it is also an important factor in predicting changes in plant communities with respect to different management strategies.

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Appendix 1: All understorey species recorded within the Eden Burning Study Area, highlighting those that have been recorded in the soil seedbank study. *= exotic

Family	Scientific Name	Seed bank	Obligate-Seeder
Adiantaceae	*Cheilanthes austrotenuifolia*	No	No
	Cheilanthes sieberi	No	No
Anthericaceae	*Arthropodium milleflorum*	Yes	No
Anthericaceae	*Caesia parviflora*	Yes	No
	Thysanotus tuberosus	Yes	No
Apiaceae	*Daucus glochidiatus*	No	Yes
	Platysace lanceolata	Yes	No
	Xanthosia dissecta	No	No
	Xanthosia pilosa	Yes	Yes
	Xanthosia tridentata	Yes	Yes
Araliaceae	*Polyscias sambucifolia*	No	No
Asclepiadaceae	*Tylophora barbata*	No	No
Asteraceae	*Arrhenechthites mixta*	No	Yes
	Cassinia aculeata	No	Yes
	Cassinia longifolia	Yes	Yes
	Cassinia trinerva	No	Yes
	**Conyza albida*	No	Yes
	Euchiton gymnocephalum	Yes	Yes
	Helichrysum argophyllum	No	Yes
	Helichrysum baxteri	Yes	Yes
	Helichrysum leucopsideum	Yes	No
	Helichrysum obcordatum	No	Yes
	Helichrysum scorpioides	No	No
	**Hypochaeris radicata*	No	No
	Lagenifera stipitata	Yes	No
	Leptorhynchos nitidulus	No	No
	Olearia erubescens	No	No
	Olearia ramulosa	Yes	Yes
	Ozothamnus cuneifolius	Yes	Yes
	Ozothamnus diosmifolius	No	Yes
	Senecio linearifolius	No	Yes
Baueraceae	*Bauera rubioides*	No	No
Bignoniaceae	*Pandorea pandorana*	No	No
Blechnaceae	*Blechnum cartilagineum*	No	No
	Blechnum nudum	No	No
Boraginaceae	*Heliotropium brachygyne*	No	Yes
Campanulaceae	*Wahlenbergia gracilis*	Yes	No
Caryophyllaceae	*Stellaria flaccida*	No	Yes
Casuarinaceae	*Allocasuarina littoralis*	Yes	No
Centrolepidaceae	*Centrolepis strigosa*	Yes	No
Clusiaceae	*Hypericum gramineum*	No	No
	Hypericum japonicum	Yes	No
Colchicaceae	*Burchardia umbellata*	No	No
Convolvulaceae	*Dichondra repens*	Yes	No
Crassulaceae	*Crassula helmsii*	No	Yes
Crassulaceae	*Crassula sieberiana*	Yes	Yes
Cyatheaceae	*Cyathea australis*	No	No
Cyperaceae	*Caustis flexuosa*	Yes	No
	Cyperus tenellus	No	Yes
Family	**Scientific Name**	**Seed bank**	**Obligate-Seeder**
	Gahnia clarkei	Yes	No
	Gahnia melanocarpa	No	No
	Gahnia radula	Yes	No
	Gahnia sieberiana	No	No
	Lepidosperma filiforme	No	No
	Lepidosperma gladiatum	No	No
	Lepidosperma laterale	Yes	No
	Lepidosperma lineare	No	No
	Lepidosperma urophorum	No	No
	Schoenus maschalinus	Yes	No
	Schoenus melanostachys	Yes	No
Dennstaedtiaceae	*Pteridium esculentum*	No	No
Dicksoniaceae	*Calochlaena dubia*	No	No
Dilleniaceae	*Hibbertia empetrifolia*	Yes	No
	Hibbertia obtusifolia	No	No
	Hibbertia serpyllifolia	No	No
Droseraceae	*Drosera auriculata*	Yes	No
Elaeocarpaceae	*Elaeocarpus reticulatus*	No	No
Ericaceae (Epacridaceae)	*Acrotriche serrulata*	No	No
	Astroloma humifusum	No	No
	Brachyloma daphnoides	No	No
	Epacris impressa	Yes	No
	Leucopogon ericoides	Yes	Yes
	Leucopogon lanceolatus	Yes	No

Family	Scientific Name	Seed bank	Obligate-Seeder
	Leucopogon microphyllus	Yes	Yes
	Leucopogon virgatus	No	No
	Monotoca scoparia	Yes	No
Euphorbiaceae	*Amperea xiphoclada*	Yes	No
	Poranthera microphylla	Yes	Yes
Fabaceae (Faboideae)	*Aotus ericoides*	Yes	No
	Bossiaea buxifolia	No	No
	Bossiaea obcordata	No	No
	Bossiaea prostrata	Yes	No
	Daviesia buxifolia	Yes	No
	Daviesia ulicifolia	Yes	No
	Dillwynia sericea	No	Yes
	Glycine clandestina	Yes	No
	Gompholobium glabratum	No	Yes
	Gompholobium huegelli	No	Yes
	Hardenbergia violacea	Yes	No
	Hovea heterophylla	No	No
	Hovea linearis	No	No
	Indigofera australis	No	No
	Kennedia prostrata	No	Yes
	Kennedia rubicunda	No	Yes
	Oxylobium ilicifolium	No	No
	Platylobium formosum	No	No
	Pultenaea daphnoides	Yes	Yes
	Pultenaea linophylla	No	Yes
	Pultenaea retusa	Yes	Yes
	Pultenaea viscosa	No	Yes
	Sphaerolobium vimineum	No	Yes
Fabaceae (Mimosoideae)	*Acacia dealbata*	Yes	Yes
	Acacia falciformis	No	No
	Acacia floribunda	No	Yes
	Acacia implexa	No	Yes
	Acacia longifolia	Yes	Yes
	Acacia mearnsii	No	Yes
	Acacia mucronata	No	No
	Acacia myrtifolia	Yes	Yes
	Acacia obtusifolia	No	Yes
	Acacia rubida	No	Yes
	Acacia terminalis	Yes	Yes
	Acacia ulicifolia	No	Yes
	Acacia verticillata	No	Yes
Gentianaceae	*Centaurium erythraea*	Yes	Yes
Geraniaceae	*Pelargonium inodorum*	Yes	Yes
Gleicheniaceae	*Gleichenia microphylla*	No	No
Goodeniaceae	*Coopernookia barbata*	Yes	No
	Dampiera stricta	Yes	No
	Goodenia elongata	Yes	No
	Goodenia ovata	Yes	Yes
	Scaevola ramosissima	Yes	No
Haloragaceae	*Gonocarpus tetragynus*	No	No
	Gonocarpus teucrioides	Yes	Yes
Iridaceae	*Diplarrena moraea*	Yes	No
	Patersonia fragilis	No	No
	Patersonia glabrata	No	No
	Patersonia longifolia	No	No
Juncaceae	*Juncus pauciflorus*	No	No
	Juncus planifolius	Yes	No
Lamiaceae	*Scutellaria mollis*	No	Yes
Lauraceae	*Cassytha glabella*	Yes	Yes
	Cassytha pubescens	No	Yes
Lindsaeaceae	*Lindsaea linearis*	No	No
	Lindsaea microphylla	No	No
Lobeliaceae	*Lobelia gibbosa*	No	No
	Mitrasacme pilosa	Yes	Yes
	Mitrasacme polymorpha	No	Yes
Lomandraceae	*Lomandra confertifolia*	No	No
	Lomandra filiformis	Yes	No
	Lomandra glauca	No	No
	Lomandra longifolia	Yes	No
	Lomandra multiflora	No	No
Lycopodiaceae	*Lycopodium deuterodensum*	No	No
Myrtaceae	*Baeckea virgata*	No	No
	Callistemon citrinus	No	No
	Kunzea ambigua	Yes	Yes
	Kunzea ericoides	Yes	No
	Leptospermum attenuatum	No	No
	Leptospermum juniperinum	No	No
	Leptospermum scoparium	Yes	No
	Melaleuca squarrosa	Yes	No
Onagraceae	*Epilobium billardierianum*	No	No
Orchidaceae	*Acianthus exsertus*	No	No
	Caladenia carnea	Yes	No
	Caleana major	No	No
	Chiloglottis gunnii	No	No
	Chiloglottis reflexa	No	No
	Cymbidium suave	No	No
	Dipodium variegatum	No	No
	Diuris sulphurea	No	No
	Eriochilus cucullatus	No	No
	Lyperanthus suaveolens	No	No
	Pterostylis longifolia	No	No
	Pterostylis nutans	No	No
	Pterostylis parviflora	No	No
Oxalidaceae	*Oxalis radicosa*	No	No
Phormiaceae	*Dianella caerulea*	No	No
	Dianella revoluta	No	No
	Dianella tasmanica	No	No
	Stypandra glauca	Yes	No
Pittosporaceae	*Billardiera procumbens*	Yes	Yes
	Billardiera scandens	Yes	No
	Bursaria spinosa	No	No
Plantaginaceae	*Plantago debilis*	Yes	Yes
Poaceae	*Anisopogon avenaceus*	No	No
	Austrostipa nervosa	No	No
	Danthonia pallida	No	No
	Danthonia pilosa	No	No
	Deyeuxia quadriseta	No	No
	Dichelachne rara	Yes	No
	Entolasia stricta	Yes	No
	Hierochloe rariflora	Yes	No
	Imperata cylindrica	No	No

	Microlaena stipoides	Yes	No
	Oplismenus imbecillis	Yes	No
	Poa labillardieri	No	No
	Poa meionectes	No	No
	Stipa pubescens	No	No
	Tetrarrhena juncea	Yes	No
	Themeda australis	No	No
Polygalaceae	*Comesperma ericinum*	No	Yes
	Comesperma volubile	No	No
Proteaceae	*Banksia marginata*	No	Yes
	Banksia serrata	No	No
	Banksia spinulosa	No	No
	Hakea eriantha	No	Yes
	Hakea sericea	No	Yes
	Lomatia ilicifolia	No	No
	Persoonia confertiflora	No	No
	Persoonia levis	No	No
	Persoonia linearis	Yes	No
	Perssonia lucida	No	No
Ranunculaceae	*Clematis aristata*	No	No
Restionaceae	*Empodisma minus*	Yes	No
	Leptocarpus tenax	No	No
Rhamnaceae	*Pomaderris andromedifolia*	No	Yes
	Pomaderris lanigera	Yes	Yes
	Pomaderris ligustrina	No	Yes
	Pomaderris multiflora	No	Yes
Rubiaceae	*Coprosma quadrifida*	No	No
	Galium binifolium	Yes	Yes
	Galium liratum	No	Yes
	Opercularia aspera	Yes	Yes
	Opercularia varia	Yes	Yes
	Pomax umbellata	Yes	Yes

Family	**Scientific Name**	**Seed bank**	**Obligate-Seeder**
Rutaceae	*Correa reflexa*	Yes	No
Santalaceae	*Choretrum pauciflorum*	No	No
	Exocarpos cupressiformis	No	No
	Exocarpos strictus	No	No
Santalaceae	*Omphacomeria acerba*	No	No
Sapindaceae	*Dodonaea triquetra*	Yes	Yes
Schizaeaceae	*Schizaea bifida*	No	No
Scrophulariaceae	*Gratiola peruviana*	No	Yes
	Veronica calycina	Yes	No
	Veronica plebeia	No	No
Selaginellaceae	*Selaginella uliginosa*	Yes	No
Solanaceae	*Solanum pungetium*	Yes	Yes
Stackhousiaceae	*Stackhousia monogyna*	No	No
Sterculiaceae	*Lasiopetalum ferrugineum*	No	No
	Lasiopetalum macrophyllum	Yes	No
Stylidiaceae	*Stylidium graminifolium*	Yes	No
Thymelaeaceae	*Pimelea curviflora*	No	No
Tremandraceae	*Tetratheca pilosa*	Yes	No
	Tetratheca thymifolia	No	Yes
Uvulariaceae	*Schelhammera undulata*	No	No
Violaceae	*Viola hederacea*	Yes	Yes
	Viola sieberiana	No	No
Xanthorrhoeaceae	*Xanthorrhoea concava*	No	No
	Xanthorrhoea resinifera	No	No

Adopting national vegetation guidelines and the National Vegetation Information System (NVIS) framework in the Northern Territory

Donna L. Lewis[1]*, Peter B. Brocklehurst*[1]*, Richard Thackway*[2] *and Jason V. Hill*[1]

[1] Dept of Natural Resources Environment & the Arts, PO Box 496 Palmerston, NT 0831, AUSTRALIA.
[2] Bureau of Rural Sciences, GPO Box 858 Canberra, ACT 2601, AUSTRALIA. Corresponding author: donna.lewis@nt.gov.au

Abstract: Guidelines and core attributes for site-based vegetation surveying and mapping developed for the Northern Territory, are relevant to botanical research, forestry typing, rangeland monitoring and reporting on the extent and condition of native and non-native vegetated landscapes. These initiatives are consistent with national vegetation guidelines and the National Vegetation Information System (NVIS) framework. This paper provides a synopsis of vegetation site data collection, classification and mapping in the Northern Territory, and discusses the benefits of consistency between the guidelines, core attributes and the NVIS framework; both of which has an emphasis on the NVIS hierarchical classification system for describing structural and floristic attributes of vegetation.

The long-term aim of the NVIS framework is that national attributes are adopted at regional levels to enable comparability of vegetation information within survey and jurisdictional boundaries in the Northern Territory and across Australia. The guidelines and core attributes are incorporated in current and future vegetation survey and mapping programs in the Northern Territory.

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Introduction

Information on vegetation in Australia is increasingly required at a range of spatial scales and levels of attribute detail, for regulatory, management and planning purposes. There have been a number of attempts to develop a consistent, comparable and Australia-wide approach to native vegetation mapping and compilation. The Australian Native Vegetation Assessment (NLWRA 2001) presents the first regional-level comprehensive guidelines for assessing and reporting Australia's native vegetation resources, including their extent and change since European settlement.

The National Vegetation Information System (NVIS) is an Australian vegetation information framework developed with States and Territories over the past decade to bring together vegetation datasets into one repository. The aim of NVIS is to improve the comparability and consistency of vegetation information across the continent. http://www.environment.gov.au/erin/nvis/index.html NVIS allows the compilation of spatial and non spatial vegetation datasets and provides a means of describing and representing vegetation information based on relationships between structural and floristic data. As a storage system its set of core attributes facilitate analysis and reporting of Australia's vegetation resources.

Since 1999 the Northern Territory has recognised inconsistencies in vegetation datasets, resulting from different data collection and classification methods, and developed guidelines and field methods for vegetation survey and mapping (Brocklehurst et al., 2007). The guidelines are a concise account of the national vegetation guidelines and provide reference to revised vegetation chapters of the colloquially known 'yellow book' (Hnatiuk et al., in press) and 'blue book' (Thackway et al., 2008).

Vegetation datasets generally incorporate qualitative and quantitative attributes to describe and map vegetation. Numerous terms are used to describe vegetation including alliance, society, association, type and community. The last term is defined as an assemblage of plant species which are structurally and floristically similar and form repeating units across a landscape (ESCAVI 2003). The generic term vegetation will be used throughout this paper in the context of the definition provided.

Mapped information on vegetation varies in terms of spatial scale, accuracy and level of attribute detail. Spatial changes in naturally occurring vegetation can be influenced by species composition, structural attributes including cover, height, growth form and seasonal responses (Mueller-Dombois &

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Ellenberg 1974). Apart from environmental correlates (such as elevation, soils, aspect and latitude), local and regional spatial patterns observed in native vegetation can be strongly influenced by natural perturbations such as cyclones, wildfire, drought and insect damage. Vegetation mapping is an applied science that attempts to depict features from a remotely-sensed interpretive base at a point in time and provides a static descriptive view of the vegetation contained (Thackway et al., 2008; Wallace et al., 2006).

This paper provides a synopsis of vegetation site data collection, classification and mapping in the Northern Territory. Discussed are the linkages of the Northern Territory guidelines and soon to be published national vegetation guidelines for conducting, classifying, describing and mapping vegetation, including Hnatiuk et al. (in press), Thackway et al. (2008) and the Australian Vegetation Attribute Manual (ESCAVI 2003). The development of core attributes for vegetation site-based and map unit data for historic and future vegetation datasets is presented. We also highlight approaches promoting knowledge and adoption of Northern Territory and national vegetation guidelines through seminars and workshops.

National vegetation information

To describe, classify and map vegetation at the national level, several approaches have been developed. These have included new or primary mapping datasets and compiling existing mapped vegetation information. Vegetation datasets have included native, non-native and non-vegetated cover types.

Perhaps the most widely recognised national map of Australia's vegetation is that of John Carnahan (Carnahan 1976, AUSLIG 1990) which used new or primary mapping to characterise Australia's natural vegetation at 1:5 000 000 scale for both pre-European and present (1980) extent.

In the early 1990s the National Forest Inventory (NFI) began to regularly compile available mapped information on forest types (Brack 2007). This dataset includes various spatial scales, levels of attribute detail and currency. In 1999 the National Land and Water Resources Audit commenced development of NVIS as a basis for regularly compiling the best available mapped information on vegetation types (NLWRA 2001). This approach translates and compiles maps of vegetation for pre-European and present extent and includes various spatial scales, levels of attribute detail and currency. Compilation of State and Territory vegetation datasets for NFI and NVIS datasets, showed numerous disparities, largely due to different methods used to classify and map vegetation. Since the early 2000s developers of NVIS have played a fundamental role in establishing comprehensive and systematic national guidelines for field-based vegetation survey (Hnatiuk et al., in press), standard vegetation classification and map attribution techniques (Thackway et al., 2008) and for compiling existing State and Territory datasets into one national dataset (ESCAVI 2003).

Vegetation classification systems and national vegetation guidelines

Classification systems are fundamental for vegetation description, to define patterns and simplify complex vegetation data. A classification system comprises classes that impose artificial boundaries on continuous variables. Various vegetation classification systems are used throughout Australia (Beadle 1981; Beadle & Costin 1952; Floyd 1990; Specht 1970; Specht et al., 1974; Walker & Hopkins 1990; Webb 1968), the majority are similar and use floristics, structure and physiognomy to distinguish vegetation (Sun et al., 1997).

Several Australian States have developed vegetation classifications for use in land use regulations or environmental assessment. Regional Ecosystems (Sattler & Williams 1999) are applied under clearing laws in Queensland. The Department of Environment and Sustainability in Victoria has developed and mapped Ecological Vegetation Classes that guide many decisions in that State. In NSW, a non-spatial plant community classification (NSW Vegetation Classification and Assessment database) described in Benson (2006) has so far covered the semi-arid and arid plains of that State (Benson et al., 2006) and the NSW South Western Slopes bioregion (Benson in review). The NSWVCA is used in the assessment of land development or conservation incentive proposals in the Property Vegetation Planning Biometric Tool (Gibbons et al., 2005) in NSW.

Vegetation classification in the Northern Territory has traditionally used a modified Carnahan (1976) and Specht (1981) system. The Northern Territory vegetation map (Wilson et al., 1990) altered the Specht (1981) system to characterise vegetation by the tallest stratum if vegetative cover was greater than 5%. If the tallest stratum was less than 5% cover, a lower stratum became the dominant or most characteristic. The Northern Territory's vegetation mapping program maintained this approach in successive vegetation survey and mapping projects. However, as independent surveys were instigated by other agencies, methods were modified and other classification systems introduced.

Specht (1970) devised a two-way structural classification scheme for vegetation formations based on life form, height and projective foliage cover (PFC) of the tallest stratum. This system has three height classes and four PFC classes and is possibly the most widely applied classification system in Australia (Sun et al., 1997), although lacking a floristic component. The classification system widely used for integrated surveys was Walker and Hopkins (1990) which characterises vegetation by the tallest stratum and aims to provide a single vegetation classification scheme. Walker and Hopkins (1990) is based on the Specht (1970) approach and uses physiognomy, height and crown cover complemented by dominant or diagnostic species. Crown cover in this instance treat canopies as opaque and is considered less time-consuming to collect in the field than PFC.

The two systems rely on slightly different criteria, for example height, cover and structural formation classes are not consistent. As a consequence once areas are mapped using the respective approaches, resultant maps are not directly comparable. Another factor to consider when classifying vegetation is the concept of 'real values' versus 'predefined classes'. The Braun-Blanquet (1932) cover abundance scale has also been used in the Northern Territory and is designed for estimating species abundances. This method is modified from Mueller-Dombois and Ellenberg (1974) and does not define actual cover values, making it difficult to relate vegetation data to other classification systems.

During the compilation of national, State and Territory vegetation datasets for the Australian Native Vegetation Assessment (NLWRA 2001), the NVIS framework had difficulty comparing and joining datasets, because of the different classification systems underpinning them, and the need for national vegetation guidelines was recognised. The opportunity also arose to revise vegetation chapters of the 'yellow book' vegetation – guidelines for site-based survey (Walker & Hopkins 1990) and 'blue book' vegetation – guidelines for conducting surveys (Pedley 1988) and replace them with Hnatiuk et al. (in press) and Thackway et al. (2008) respectively. This strategic opportunity was supported by NVIS developers.

The national vegetation guidelines can be applied to native (including rainforest) and non-native vegetation. Wetlands and rainforests are treated as a separate classification within the national guidelines. Wetlands are defined by the Ramsar Convention (Anonymous 1994) and rainforests include two special cases separately 1) tropical and subtropical rainforests, and 2) Tasmanian rainforests. Due to structural complexity these two varieties of rainforest may be sampled using either standard classification or methods supplemented with extra structural attributes. Dry rainforests in the Northern Territory, Western Australia and parts of Queensland, and temperate rainforests in south eastern mainland Australia are classified using standard methods. The guidelines also include procedures to add more detail by assessing growth stage and condition.

Northern Territory approaches to vegetation survey and mapping

The Northern Territory occupies 18% of Australia and covers a range of environments and climatic regimes. In comparison to other States and Territories, it still retains large areas of uncleared native vegetation, and although not pristine, can be regarded as relatively intact and not fragmented. The environments range from wet/dry tropics in the north to semi-arid and arid regions in central Australia. The patterning of vegetation generally becomes broader as it progresses north to south, particularly from 18° south.

Many agencies within the Northern Territory and Commonwealth governments, universities and private industry are responsible for collecting vegetation data for an array of purposes including map unit interpretation, monitoring, flora and fauna surveys, carbon sequestration and environmental impact assessments. Applications for vegetation information include park management plans, habitat recognition, land cover change, mine site rehabilitation, vegetation retention for biodiversity conservation and to implement the Northern Territory land clearing regulations and controls (NRETA 2006).

Overall, vegetation information in the Northern Territory has been collected, described and classified using different methods and classification systems. Vegetation information can be categorised into site-based data and map unit data (vegetation mapping datasets). Map unit data across the Northern Territory comprises vegetation mapping and integrated surveys. There are two types of integrated surveys; land unit (finer spatial scale) and land system (broader spatial scale) surveys. A land unit is defined as a reasonably homogenous component of the land surface, distinct from surrounding terrain and is characterised by landform, soil and vegetation (Hooper 1970). Land systems are defined as an area, or group of areas throughout which there is a re-occurring pattern of topography, soils and vegetation, a term first described by Christian and Stewart (1953). Each land system is recognised as an assemblage of land units.

Site-based approaches

Ecological surveys prior to the 1950s were rare and botanical collections provide the only access to vegetation site-based data. Also limited published information on Northern Territory flora was available and the lack of taxonomic literature made site-based survey difficult.

Numerous sectoral groups collect site-based vegetation data for ecological, pastoral, biodiversity and botanical purposes. Attributes collected at sites generally incorporate floristic composition, structural characteristics and environmental information. However, the data collected by the different sectoral groups often varies in terms of attribute information, level of detail and classification system used.

The Department of Natural Resources, Environment and the Arts (NRETA) administers several divisions who are primary collectors of vegetation information. The Land and Vegetation Branch are the main collectors of site-based vegetation data to underpin vegetation mapping and integrated surveys. Current site-based data incorporates full floristics and structural characters including cover, height and growth form with a strong emphasis on strata. Other NRETA divisions collect and describe vegetation data with less emphasis on strata and species dominance. Data is generally collected in conjunction with fauna surveys for habitat recognition. Data collected by the Northern Territory Herbarium is primarily for floristic inventories, rare and threatened species records and taxonomic treatments. Associated data incorporates minimal structural characteristics and broad descriptive information (Brocklehurst 2003).

Map-based approaches

The first systematic vegetation survey and mapping in the Northern Territory was instituted by the Conservation Commission (now NRETA) following a feasibility study (Dickinson & Kirkpatrick 1985). Recommendations from this study resulted in formation of the Vegetation Mapping Unit, an autonomous group to develop a vegetation mapping program for the entire Northern Territory. The program resulted in a vegetation map at 1:1 000 000 spatial scale (Wilson et al., 1990) recognising 112 broad vegetation communities delineated from satellite imagery and numerical classification of 2 245 sites sampled for floristic and structural attributes. This information provided an ecological perspective of the Northern Territory and assisted with the bio-geographic regionalisation and other broad scale applications.

Another widely used vegetation map is the vegetation map of Northern Australia (Fox et al., 2001). Vegetation was mapped at 1:2 000 000 spatial scale across the tropical savanna region of Western Australia, the Northern Territory and Queensland. The map was compiled from existing and new information. This dataset has numerous applications one of which was to fill information gaps in the Australian vegetation database (NVIS).

Since the mid 1980s numerous local and regional scale vegetation maps with spatial scales ranging from 1:5 000 to 1:250 000 have been produced for small geographic areas. Figure 1 shows discrete area vegetation mapping datasets. Specific vegetation mapping datasets are not portrayed, although they do exist across particular regions and largely include vegetation mapped by genera or species and vegetation such as mangroves and monsoon rainforest. The mapping of structural characteristics such as PFC also exists across the Top End (Meakin et al., 2001). Less than 1% of the Northern Territory's vegetation is mapped at a spatial scale of 1:50 000 or less and approximately 7.5% either 1:100 000 or 1:250 000 (Table 1).

The most up-to-date vegetation dataset is NTNVIS (Version 3), a derivative of the national NVIS (Version 3) dataset. It includes both a pre-European (pre development) and present vegetation data and recognises 174 distinct vegetation types. Essentially NTNVIS is an amalgamation of the 1:1 000 000 vegetation mapping (Wilson et al., 1990) and finer spatial scale datasets and therefore contains a range of spatial scales. The attribute information is consistent for all surveys and is contained in the NVIS oracle database. Publicly accessible versions of NTNVIS (Version 3) are attributed with a subset of NVIS attributes, namely the NVIS Information Hierarchy. The Information Hierarchy is based on six levels of structural and floristic information. The threshold for input of vegetation description data into the NVIS database is NVIS Level V (Association) (Appendix 1).

The NTNVIS dataset is the Northern Territory component of NVIS. Since 1999, a number of data supplies from each State and Territory have occurred leading to a number of NVIS versions. Version 3 is based on data collated in 2005, Version 2 contains detailed Level V (Association) data following a restructure of the NVIS database and Version 1 is the original NVIS supply released in 2001.

The benefits of using NVIS are various. Standardisation of vegetation descriptions provide a basis to compare datasets with different mapping methods and/or spatial scales and assist in identifying equivalent vegetation. Users of Northern Territory vegetation mapping datasets are encouraged to use the NTNVIS (Version 3) dataset.

Several applications of the original 1:1 000 000 vegetation map and NTNVIS dataset has highlighted the importance for finer spatial scale vegetation mapping across the Northern Territory. In particular, the reservation status assessment of vegetation recognised 1:1 000 000 as coarser than desirable for reserve planning (Woinarski et al., 1996), and recommended spatial scales of 1:100 000 or 1:250 000. Limitations are most profound for vegetation which occur in small isolated patches such as monsoon rainforests (Price et al., 1995). There has been no comprehensive and systematic re-mapping of vegetation in the Northern Territory since the production of 1:1 000 000 vegetation map in 1990.

Table 1. Vegetation spatial mapping scales in the Northern Territory (Brocklehurst pers. com.).

Spatial scale	Area km²	% NT Coverage	Significance	Datasets
≤ 1:50 000	7 662	0.6	Local*	Various
1:100 000 -1:250 000	100 898	7.5	Regional*	Various
1:1 000 000	1 346 200	100	National	1:1 000 000 pre-European NT vegetation map
1:100 000 – 1: 1 000 000 mixed scale	1 346 200		National/Regional	NVIS Version 3.1 pre-European NT vegetation map & NVIS Version 3.1 present vegetation map

* approximately 8% of Northern Territory mapped at regional or local spatial scales

Integrated surveys

Aside from vegetation mapping, integrated surveys, describing landform, soil and vegetation within one map unit, have dominated land resource mapping. Land units are typically generated at spatial scales between 1:25 000 and 1:100 000 and land systems between 1:100 000 and 1:250 000 (Fig 2). Traditionally the primary focus of integrated surveys was to identify agricultural soil landscapes whilst taking into account other landscape features such as vegetation (Aldrick & Robinson 1972). Vegetation attributes for integrated surveys were not generally described at the same level of detail as soil landscape properties. vegetation attributes in earlier surveys comprised structure and dominant species in all characteristic strata.

The first integrated surveys were conducted by CSIRO in 1946 in the Katherine and Darwin region and the approach continued to target important pastoral regions across the Northern Territory. In the late 1960s, the Northern Territory Government adopted the land system approach developed by CSIRO and progressed a unique land unit method to describe and map landscapes (Hooper 1970; Laity 1971).

Integrated surveys in the Northern Territory are still undertaken where pedologists and ecologists concurrently record information at identical field sites. The level and quality of vegetation data varies according to project aims and staff availability. In the past, at least a qualitative assessment of structural characteristics and dominant species were recorded. Over the past decade surveys have incorporated full floristics, structural characteristics and physiognomy (Hill 2004; Napier & Steen 2002). These and future integrated surveys, if not already, will be compliant with Northern Territory and national vegetation guidelines for collecting, classifying and mapping vegetation.

Core attributes and vegetation information infrastructure

The development of national vegetation guidelines has been a key driver towards addressing current vegetation information infrastructure in the Northern Territory. Vegetation site-based databases are the basis of vegetation mapping programs largely to classify vegetation and assist in providing map attribution. Upon completion of a vegetation

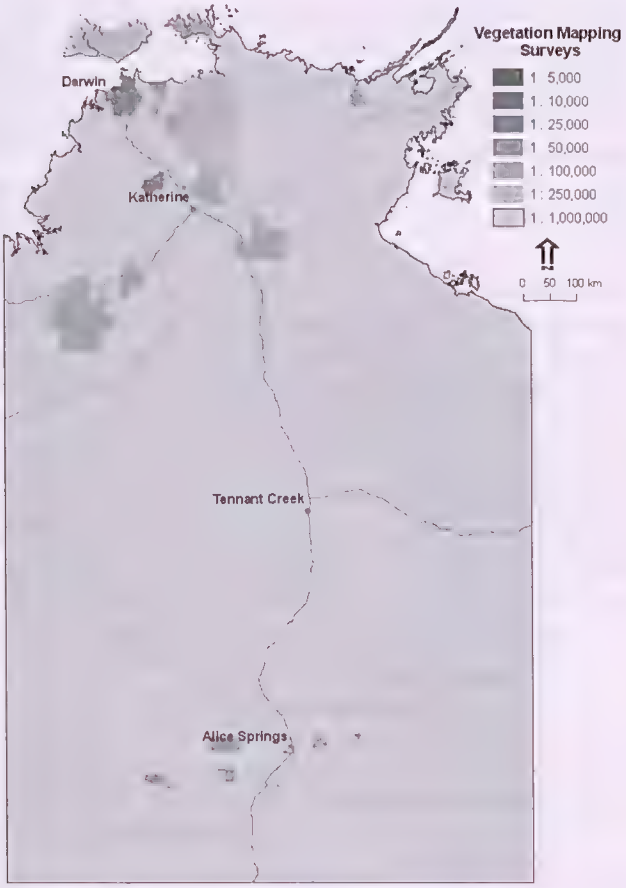

Fig. 1. Extent of discrete area spatial scale vegetation mapping surveys in the Northern Territory.

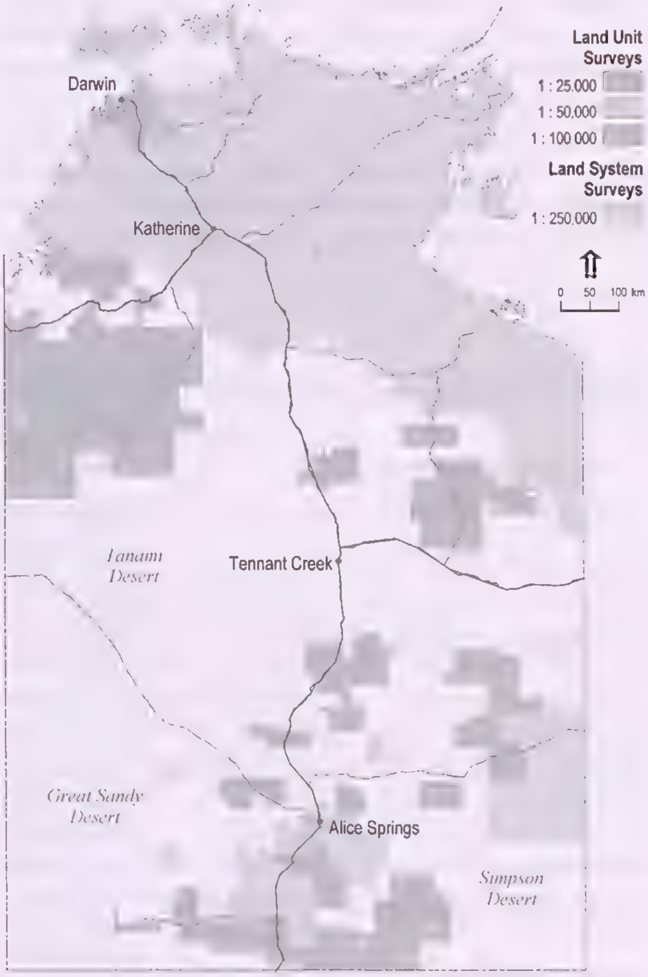

Fig. 2. Extent and spatial scales of integrated surveys in the Northern Territory.

map, these datasets become part of a corporate spatial data archive. Datasets are made available to users including the public via servers and web-based applications.

Core attributes have been developed for collecting and compiling site-based and map unit vegetation datasets. The aim of these is to promote consistency between agencies collecting data and increase data sharing capacity. Core attributes attempt to reduce data entry, simplify querying vegetation information across adjoining surveys and assist the Northern Territory with national reporting requirements.

Site data

Numerous site-based databases are maintained by various government agencies. An inventory was undertaken in 2003 primarily to asses the feasibility of historic site data to generate a listing of vegetation types in the Northern Territory (Brocklehurst 2003). The inventory assessed and compiled information on site data location, number of sites and an estimate of site detail and quality for approximately 250 surveys and over 30 000 sites. The inventory suggests approximately 66% of site data are stored electronically. The majority of sites are digital with about 56% collected in conjunction with mapping programs (Brocklehurst 2003). The digital site data is stored in a number of different software packages and applications maintained by several custodians. The inventory also showed there is no centralised vegetation site database in the Northern Territory, nor is there an agreed set of attributes. There are number of major impediments including no standard definition of attributes, some data is non digital (paper copy), detail of existing data varies and data continues to be collected, described and stored inconsistently.

The existing Resource Assessment Vegetation System (RAVS) Oracle database maintained by NRETA's Land and Vegetation Branch is currently being redeveloped. The intention of the web-enabled database is to become the centralised repository for Northern Territory vegetation site-based data. The database will be developed to allow government and non government custodians to view, enter, edit and retrieve data for particular surveys across the Northern Territory. Surveys existing in the database are consistent with national vegetation guidelines and the NVIS framework.

Contained in the database are mandatory fields that incorporate core attributes divided into five categories (Lewis et al., 2007b) (Table 2). Core attributes ensure data across surveys are comparable. The number of fields within each category at a given site is constant with the exception of the 'stratum' field. The number of fields for 'stratum' are dependent on the number of strata identified at a given site location. Up to eight sub-strata may be identified based on the NVIS framework; traditionally up to three are recognised in the Northern Territory.

Map unit data

Completed vegetation surveys and mapping datasets including reports are stored and managed in an oracle dissemination database on behalf of the Northern Territory's data custodians including government and non government agencies and the general public.

Table 2. Northern Territory vegetation site data core attributes.

Core Attribute Category	Field Code	Field Name
1) Survey	SURVEY_NAME	Survey Name
	SURVEY_ID	Survey Identifier
	SITE	Site Number
	DATE	Site Sample Date
2) Location and Geo-referencing	LONG	Latitude
	LAT	Longitude
3) Landform	LAND_PAT	Landform Pattern
	LAND_ELE	Landform Element
4) Broad Vegetation	NVIS_CODE	NVIS Structural Formation Code
	STRU_FORM	Structural Formation
	COM_ DESC	Vegetation Community Common Language Description
5) Stratum	GRTH_FORM	Dominant Growth Form
(Information is recorded for each identified Strata U, M, G	COV_TYPE	Cover Type
	COV_%	Cover Percentage
OR Sub-strata U1, U2, U3, M1, M2, M3, G1, G2)	HGT_TYPE	Height Type
	HGT_AVE	Height Average
	HGT_RANGE	Height Range
	SPECIES	Dominant Species List

Source: Lewis et al. (2007b)

Mapped vegetation datasets are one of many natural resource datasets that are archived. The archive includes digital vegetation datasets of surveys in various formats and at specific spatial scales. Accompanying reports, maps and in some situations interpretive maps are available. A digital data summary and a link to metadata describing each dataset are provided. External users to Northern Territory Government agencies can access data via digital data agreements.

Portions of spatial data maintained on the spatial archive are made available on a web enabled mapping application called NRETA Maps www.nt.gov.au/nretamaps.

The primary purpose of this application is data discovery and interrogation of natural and cultural resource data and information available to Northern Territory Government agencies and the general public. Themes currently available include vegetation, land, water, parks and wildlife, biodiversity, maps, reports and projects. Also included are base layers such as topography, land administration, infrastructure, satellite imagery and aerial photography and offers several functions including basic downloads and map creation.

Core map unit attributes are derived partly from the NVIS Information Hierarchy, a subset of the NVIS attribute entirety with thirteen attributes defined (Lewis et al., 2007a) (Table 3). The NVIS Information Hierarchy is the chief system for describing structural and floristic information. Collectively, the different levels in the hierarchy provide a description of vegetation linked directly to precise spatial areas on a vegetation map.

Historic mapping datasets that are not incorporated in NTNVIS (Version 3) require core attributes to allow comparability across survey boundaries. To assist in this process a program has been developed to build the NVIS Information Hierarchy from structural and floristic components. The first vegetation survey attributed with the NVIS framework core attributes is the Stray Creek Catchment Vegetation Survey (Lewis 2005). Datasets attributed with map unit core attributes are available on NRETA Maps www.nt.gov.au/nretamaps.

The way forward is for existing surveys and in some instances integrated surveys to be assigned core attributes and be available on the NRETA spatial data server and NRETA Maps. Future vegetation surveys should first be entered into the NVIS oracle database currently being developed.

Discussion

Spatial scales, currency and limitations in Northern Territory mapping

Under the national vegetation guidelines and NVIS framework, the Northern Territory is divided into two mapping zones. The intensive land-use zone (ILZ) occupies most of north-west portion of the Northern Territory and includes major urban areas, peri urban areas as well as agricultural and pastoral zones covering Darwin, Pine Creek and Victoria River District (VRD) bioregions. The extensive land-use zones (ELZ) cover the western portion of the Top End and southern arid regions of the Northern Territory and include aboriginal lands and pastoral areas.

Benchmarks for vegetation mapping spatial scales include 1:100 000 or better in the ILZ and 1:250 000 in the ELZ. Likewise benchmarks for currency are 12 months for priority vegetation including wetlands, riparian and remnant vegetation and 18 months for agricultural lands (ILZ) and pastoral/rangelands (ELZ). Table 4 shows that the current status of Northern Territory vegetation datasets do not meet national benchmarks.

The most recent Northern Territory wide vegetation mapping dataset is NTNVIS (Version 3) discussed previously. The finer spatial scale mapping datasets incorporated are generally of discrete or lineal closed forest vegetation. Large areas of the Northern Territory still remain mapped at 1:1 000 000 and currency of circa 1986. In comparison to other States and Territories, the Northern Territory vegetation mapping remains at the broadest of spatial scales. The smaller more developed and populated States have finer spatial scale datasets (Table 5).

The Integrated Natural Resource Management Plan (INRM) identifies the importance of vegetation information in the Northern Territory to satisfy both regional objectives and national outcomes (DIPE 2005). The INRM and the Northern Territory Parks and Conservation Master Plan (NRETA 2005) recognise the limitations of the 1:1 000 000 spatial scale vegetation map and NTNVIS (Version 3) dataset for regional applications. The need for finer spatial scale mapping of vegetation across the Territory has been identified. Thus a Natural Heritage Trust (NHT) funded NRM project and working group are currently addressing this issue (Brocklehurst pers. com.).

Northern Territory guidelines, knowledge and adoption

The need for consistent vegetation data collection, storage, description, classification and mapping was recognised by the Northern Territory Government following the Australian Native Vegetation Assessment 2001 (NLWRA 2001). To address these limitations guidelines and core attributes have been developed (Brocklehurst et al., 2007) consistent with national vegetation guidelines and NVIS. These guidelines promote the use of standardised methods, procedures and terminologies on vegetation survey and mapping and will be revised in parallel with national standards as they become available. The guidelines are obtainable via the NRETA website www.nt.gov.au/natveg.

A series of regional seminars and workshops were delivered in tropical and arid climatic zones of the Northern Territory to promote knowledge and adoption of national standards. Linkages of Northern Territory and national vegetation

Table 3. Northern Territory vegetation map unit core attributes.

Field Code	Field Name
DATASET_ID	Dataset Identification
NVIS_DATA	NVIS Dataset
NVISVEG_ID	NVIS Vegetation Identification
SOUR_CODE	Source Code
NTMU_ID	Northern Territory Map Unit Identifier
SPA_MIX	Spatial Mix
COM_DESC	Community Description
L1_CLASS	Level 1 Class
L2_STR_FOR	Level 2 Structural Formation
L3_BR_FLR	Level 3 Broad Floristic Formation
L4_SUB_FOR	Level 4 Sub-Formation
L5_ASSOC	Level 5 Association
(if fields are too long the following split applies)	
L5_ASSOC_U	*Level 5 Association Upper*
L5_ASSOC_M	*Level 5 Association Mid*
L5_ASSOC_G	*Level 5 Association Ground*
EN_DESC	Environmental Description

Source: Lewis et al. (2007a)

guidelines and NVIS were discussed. Participants included ecologists from Northern Territory, South Australia and Commonwealth government agencies, and non government agencies including environmental consultants, universities and landholders. Proceedings are available on the NRETA website www.nt.gov.au/natveg Seminars and Workshops.

Conclusions

Considerable progress has been made in the Northern Territory towards adopting and implementing national vegetation guidelines and the NVIS framework. Through strategic investment by the Northern Territory Government, vegetation information will continue to become available through the provision of accessible and NVIS compliant vegetation spatial data, information databases and web-enabled applications.

Regularly updated Northern Territory guidelines, in line with national guidelines, will encourage consistency in the future collection, classification, description and storage of vegetation information. This information will assist future finer spatial scale vegetation mapping across the Northern Territory and consequently improve on the NTNVIS (Version 3) dataset. The integration of Territory programs dealing with spatial aspects of vegetation will deliver information on proposed national initiatives such as vegetation extent and condition.

Table 4. Spatial scales and time frames for Northern Territory vegetation mapping datasets (Brocklehurst pers. com.).

Type	Nationally recommended spatial scales	NT datasets	NT spatial scales	Time frames	% NT
Wetlands, Riparian, Remnant, Priority Vegetation Types	1:25 000	Paper bark forests (*Melaleuca spp*)	1:100 000	1991	7.4%
		Monsoon rainforests	1:100 000 -1:250 000	1986	
		Mangroves	1:100 000	2001	
		Lancewood (*Acacia shirleyi*)	1:100 000 -1:250 000	1992	
		Wetlands*	1:250 000		
		Clearing dataset	1:100 000	2005	
Agricultural Lands: Intensive Landuse Zone	1:100 000 1:50 000 (preferred)	As above or NTNVIS Version 3	1:100 000 - 1:1 000 000	1986-1991#	40%
Pastoral/Rangelands: Extensive Landuse Zone	1: 250 000 1:100 000 (preferred)	NTNVIS Version 3	1:1 000 000	1986	52%
Other fine spatial scale vegetation datasets		Stray Creek, Popham Creek, Bynoe Harbour etc	≤1:50 000	1990-2005	0.6%

* defined boundaries only

# vegetation component - clearing circa 2005

Table 5. Vegetation spatial mapping scales and proportional areas and populations for Australian States and Territories (Brocklehurst pers. com.).

State/Territory	Predominant spatial scale	Extent	Management scale	Predominant Mapping Type	% of Australia	% of Aus Population
Australian Capital Territory	≤ 1:50 000	100%	local	vegetation	0.04	1.7
New South Wales	1:25 000 - 1:250 000	60%	regional/local	vegetation	10.5	33
Northern Territory	≤ 1:1 000 000	100%	national/regional	vegetation	17.5	0.9
Queensland	1:100 000 -1:250 000	90%	local/regional	ecosystems	22.5	18
South Australia	1:50 000 -1:250 000	90%	regional/local	vegetation	13	8
Tasmania	1:25 000 - 1:100 000	100%	local	vegetation	0.8	2.6
Victoria	1:25 000 - 1:250 000	100%	local	ecological vegetation classes (EVC)	3	24.6
Western Australia	1:250 000	100%	regional	vegetation	33	9.6

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Appendix 1. The NVIS Information Hierarchy.

Level	Description	Species	Growth form	Cover	Height
I	**Class***	-	1 dominant growth form for the dominant stratum	-	-
	Example	*Tree*			
II	**Structural Formation***	-	1 dominant growth form for the dominant stratum	1 cover class for the dominant stratum	1 height class for the dominant stratum
	Example	*Open woodland*			
III	**Broad Floristic Formation****	1 dominant genus name for the dominant stratum	1 dominant growth form for dominant stratum	1 cover class for dominant stratum	1 height class for dominant stratum
	Example	*Eucalyptus open woodland*			
IV	**Sub-Formation****	1 dominant genus name for each stratum (max 3 strata; i.e. for U, M, G where substantially present)	1 dominant growth form for each stratum (max 3 strata)	1 cover class for each stratum (max 3 strata)	1 height class for each stratum (max 3 strata)
	Example	*+Eucalyptus open woodland\Petalostigma tall sparse shrubland\Sorghum tussock grassland*			
V	**Association****	Up to 3 dominant species for each stratum (max 3 strata; i.e. for U, M, G where present)	Up to 3 dominant growth forms for each stratum (max 3 strata; i.e. for U, M, G where present)	1 cover class code for each stratum (max 3 strata; i.e. for U, M, G where present)	1 height class code for each stratum (max 3 strata; i.e. for U, M, G where present)
	Example	*U+ ^Eucalyptus miniata, Eucalyptus tetrodonta, Erythrophleum chlorostachys \^tree\7\r;M ^Petalostigma pubescens, Buchanania obovata, Planchonia careya\^shrub\4\r;G ^Sorghum plumosum, Heteropogon triticeus, Chrysopogon latifolius\^tussock grass\2\c*			
VI	**Sub-Association****	Up to 5 dominant species for each sub-stratum (i.e. for U1, U2, U3, M1, M2, M3, G1, G2 where present) *Indicate characteristic genus in each sub-stratum with an up arrow or hat "^". Must match characteristic growth form.*	Up to 5 dominant growth forms for each sub-stratum. *Indicate characteristic growth form with an up arrow or hat "^". Must match characteristic genus.*	1 cover class code for each sub-stratum	1 height class code for each sub-stratum
	Example	*U+ ^Eucalyptus miniata, Eucalyptus tetrodonta, Erythrophleum chlorostachys, Corymbia foelscheana, Corymbia polysciada \^tree\7\r;M ^Petalostigma pubescens, Buchanania obovata, Planchonia careya, Livistona humilis, Terminalia grandiflora\^shrub,palm,tree\4\r;G ^Sorghum plumosum, Heteropogon triticeus, Chrysopogon latifolius, Distichostemon hispidulus, Erythrophleum chlorostachys\^tussock grass,forb,tree\2\c*			

* Walker & Hopkins 1990
** NVIS (defined for the NVIS Information Hierarchy)
U – Upper stratum, M – Mid stratum, G – Ground stratum (1, 2 & 3 indicates sub-stratum)
+ denotes dominant stratum
^ denotes dominant species and dominant growth form in each identified stratum
+/- indicates a species may or may not be present

Source: ESCAVI (2003)

Wetland biodiversity in coastal New South Wales: the Wallis Lake catchment as a case study

S.J. Griffith[1] *and R. Wilson*[2]

[1]Botany – School of Environmental and Rural Science, University of New England, Armidale, NSW 2351, AUSTRALIA,
[2]3 Seddon Place, Flynn, ACT 2615, AUSTRALIA

Abstract: The floristic composition and environmental relations of wetland vegetation in the Wallis Lake catchment (32° 09'S; 152° 20'E), area 1292 km^2, on the lower North Coast of NSW are described. The catchment supports wetlands listed as Endangered Ecological Communities (NSW *Threatened Species Conservation Act 1995)* and plant species of high conservation value.

A methodology of air photo interpretation, site-based sampling (114 quadrats) and landscape differentiation was developed. A total of 393 vascular plant taxa were recorded (including 10% exotics). Wetland vegetation formations and subformations including mangrove forest, swamp sclerophyll forest, wet heathland, chenopod shrubland, tussock grassland, sedgeland and rushland are described using numerical classification. 31 plant species of national or regional conservation significance are identified. Four Endangered Ecological Communities are discussed – Coastal Saltmarsh, Swamp Oak Floodplain Forest, Swamp Sclerophyll Forest on Coastal Floodplains, and Freshwater Wetlands on Coastal Floodplains.

A key recommendation is the completion of reliable wetland vegetation and soil landscape mapping for all land tenures in the catchment – to assess wetland condition and conservation significance, and representation in formal conservation reserves, thereby directing future priorities for the protection of wetland biodiversity on both public and private lands. The methodology developed can be applied to the survey and conservation of wetland biodiversity in other parts of coastal NSW.

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Introduction

This case study describes the floristic composition and environmental relations of wetland vegetation in the Wallis Lake catchment (32° 09'S; 152° 20'E) within the Great Lakes Local Government Area (LGA). It provides a methodology for the conservation and management of wetland biodiversity within a coastal catchment, and identifies the requirements of additional investigations to achieve conservation and management outcomes. The methods so developed have application to wetland conservation throughout coastal NSW.

Wallis Lake and its catchment occur on the coastal lowlands of north-eastern NSW, within the North Coast botanical subdivision (Anderson 1961) and the NSW North Coast biogeographic region (Thackway and Cresswell 1995). Open waters of the Wallis Lake estuary occupy 91 km^2, and the catchment extends over 1292 km^2. Forster and Tuncurry are major urban centres in the catchment, and smaller villages include Failford, Nabiac, Coomba Park and Pacific Palms (Figure 1).

The study is Stage 1 of a wetland strategy for Wallis Lake catchment, in preparation by Great Lakes Council (GLC). It stems from the recognition that wetlands provide ecosystem services and functions that are vital to the quality and integrity of natural systems, and in turn to the health and productivity of biodiversity, amenity and the local economy. A number of wetlands throughout the catchment are designated under State Environmental Planning Policy (SEPP) No. 14 Coastal Wetlands (Figure 2), and several wetland floristic assemblages are Endangered Ecological Communities under the NSW *Threatened Species Conservation* (TSC) *Act 1995*. Nonetheless, one of the drivers of this study is a recognition that wetlands are being cumulatively and incrementally degraded, modified, simplified or destroyed through inappropriate land uses, pressures and threats (e.g. clearing, grazing, altered fire regimes, altered hydrological regimes, weeds, feral animals, anthropogenic climate change).

Climate

The climate of coastal northern NSW is subtropical with summer-dominant rainfall, although with increasing latitude there is a gradual shift towards temperate conditions and

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relatively uniform rainfall throughout the year (Colls and Whitaker 1990).

The Bureau of Meteorology provides climatic data for Taree (rainfall 100+ years; temperature 80+ years), which is 40 km north of the Wallis Lake catchment although similar in altitude (5 m a.s.l.). The average rainfall at Taree during the three wettest months (January to March) accounts for 35% of the mean annual total (1179 mm), whereas 17% falls during the three driest months (July to September). Despite the average trends, the variability index [VI = (9th decile – 1st decile)/5th decile] for monthly rainfall ranges from 1.9–4.5. Relative to other parts of Australia these VI values are considered to be very high (1.5–2.0) or extreme (>2.0), and episodes of drought and flood are therefore likely.

Taree has a mean annual maximum temperature of 24.2°C and a mean annual minimum of 12.0°C. Mean monthly maxima are highest from December to February (28.3–28.9°C), lowest from June to August (18.4–19.9°C), and mean monthly diurnal variation is 10.9–13.9°C. Mean monthly 9 am relative humidity varies from 67–80%, and for 3 pm the range is 51–63%. Lower humidity predominantly occurs from mid-winter to late spring, which is also the period of generally lower mean monthly rainfall. Conditions of water deficit for plant growth may arise at this time when evaporation is high relative to rainfall.

Landforms, geology and soils

Extensive bedrock landforms dominate the middle and upper reaches of Wallis Lake catchment, and these vary from gently undulating rises to very steep hills and locally precipitous mountains (Murphy 2005). Outcropping strata are predominantly sedimentary, ranging in age from Devonian to Permian; common lithologies include sandstone, siltstone, mudstone and greywacke (Roberts et al. 1991). Characteristic soils include Lithosols and Red, Brown and Yellow Podzolic Soils on crests and slopes, and Soloths where there is waterlogging on lower slopes and along drainage lines (Murphy 2005).

The Coolongolook, Wallamba and Wallingat Rivers drain the catchment into Wallis Lake, which is a tidal lagoon open to the sea between Tuncurry and Forster (Figure 1). The Tuncurry and Wallis Lake bedrock embayments dominate the lower reaches of the catchment (Roberts et al. 1991). The Tuncurry embayment has formed over the last three interglacial cycles and comprises several barrier systems of

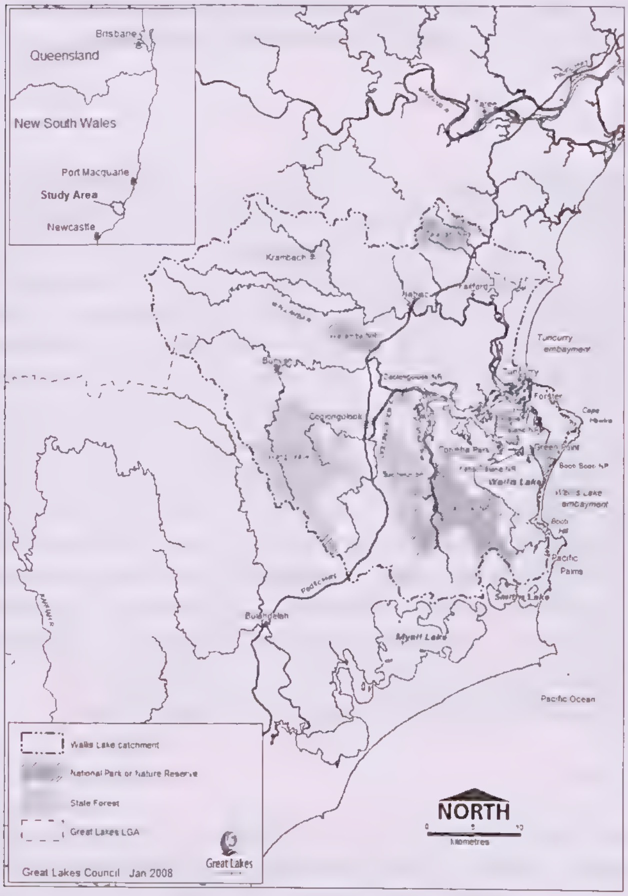


Fig. 1. Locality map of the Wallis Lake catchment.

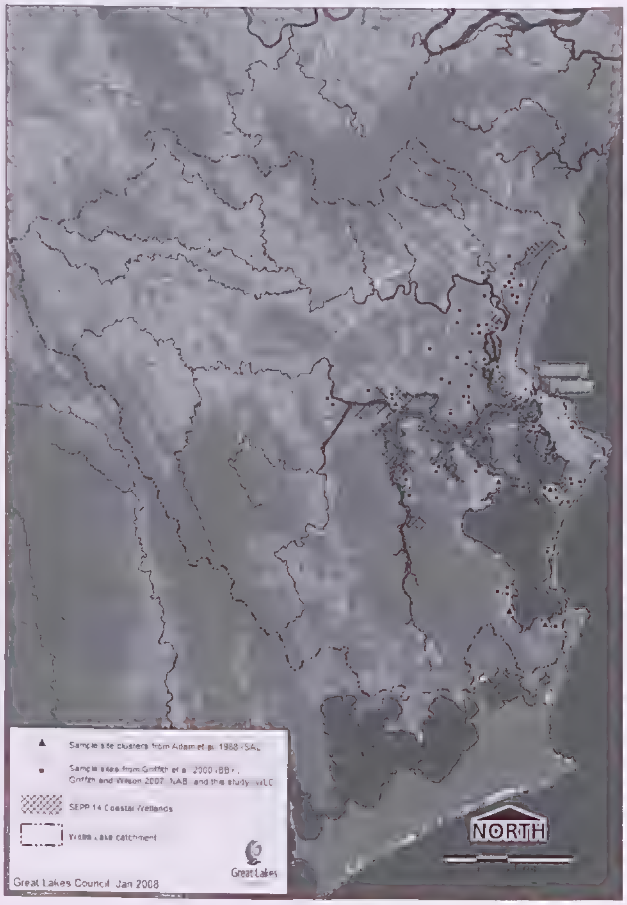

Sample site clusters from Adam et al. 1988 (SAL)
Sample sites from Griffith et al. 2000 (BB), Griffith and Wilson 2007 (KAB) and this study (WLC)
SEPP 14 Coastal Wetlands
Wallis Lake catchment
NORTH
Great Lakes
Great Lakes Council Jan 2008

Fig. 2. Location of sample sites, and wetlands designated under SEPP No. 14. Base map highlights areas cleared of native vegitation.

marine-aeolian sand with associated estuarine and alluvial deposits (Melville 1984, Murphy 2005, Roy et al. 1997). The Pleistocene Nabiac barriers, west of the Wallamba River, range in age from approximately 80 000 to 260 000 years BP. These are distinguished from the Holocene Tuncurry barrier (8 000–1 000 years BP), east of the Wallamba River, which forms the present embayment shoreline. The Coolongolook – Wallingat River system has intersected the Nabiac barriers in the south, forming Wallis Island, and the Wallamba River intersects the barriers in the north. A dominant feature of the Wallis Lake embayment is the narrow sand barrier at the present coast between the bedrock hill complexes of Cape Hawke, a former offshore island during the late Pleistocene, and Booti Hill (Melville 1984, Murphy 2005, Roy 1982). The seaward sequence of this barrier consists of Holocene marine-aeolian deposits which overlie or interface with low-lying and partly eroded Pleistocene sands, some of which are indurated. In Wallis Lake, Pleistocene sands extend to a depth of 25 m below the present sea level. The western (lake) side of the barrier consists of Pleistocene and Holocene estuarine sediments. Alluvial landforms extend along the major streams, particularly the Wallamba River and its tributaries (Murphy 2005).

Soil landscape mapping is available for much of coastal northern NSW (e.g. Atkinson 1999, Eddie 2000), although for the Wallis Lake catchment this mapping is preliminary (Murphy 2005). Soil landscapes are map units with recognisable and specific topographies and soils; and the close relationship between topography and soils is attributed to similar causal factors. Wetland vegetation in the Wallis Lake catchment is associated with transferral, alluvial, aeolian/barrier, estuarine and swamp soil landscape process groups. These soil landscape groups are defined in published studies (e.g. Atkinson 1999), and the preliminary mapping of Murphy (2005) provides brief descriptions of landform elements and soils for each group in the Wallis Lake catchment.

Transferral soil landscapes are deep deposits of eroded soil and parent materials washed downslope from adjacent bedrock hillslopes. Landform elements include footslopes, drainage plains, drainage (open) depressions and fans. Soils are moderately deep to very deep (100 to >200 cm), imperfectly to poorly drained Soloths.

Alluvial soil landscapes are formed by deposition of sediment transported by streams. Landform elements include stream channels, levees, scrolls and plains. Soils are giant (>5 m) imperfectly to poorly drained Soloths on terraces, well drained deep (>150 cm) Alluvial Soils and Prairie Soils on active floodplains, deep (>200 cm) well drained Brown Podzolic Soils and occasional Yellow Earths on levees, and poorly drained Humic Gleys in swamps. In some instances soils are potentially acid sulphate or saline at depth.

Aeolian and barrier soil landscapes result from the accumulation of sand along the coast during periods of sea level fluctuation. Beach ridge plains, dunefields and associated sandy plains are characteristic landform patterns, and landform elements include ridges (dunes, beach ridges), open depressions (swales, drainage depressions) and flats. Soils include deep (>200 cm) well drained Podzols on dunes and beach ridges, and imperfectly drained Humus Podzols in swales and on flats where there is a permanently high watertable.

Estuarine soil landscapes develop where streams enter large bodies of tidal salt water. Landform elements include stream channels, tidal flats (intertidal to supratidal) and extratidal plains. Soils include deep (>300 cm) very poorly drained Solonchaks associated with tidal flats and streams, deep (>200 cm) poorly drained Acid Peat/Siliceous Sand or Acid Peat/Humic Gley intergrades on Holocene extratidal plains, and very poorly drained very deep (>200 cm) Humic Gleys on Pleistocene estuarine clay plains. Soils that are potentially acid sulphate or saline at depth are likely on extratidal plains (former estuaries).

Swamp soil landscapes are dominated by ground surfaces that are waterlogged or inundated at least seasonally, and the soil parent material typically includes a large proportion of decayed organic matter. Swamp landscapes may be former alluvial, barrier or estuarine environments, and closed depressions (generally swamps) are the dominant landscape element. Soils include deep (>200 cm) very poorly drained Acid Peats and Acid Peat/Siliceous Sand intergrades.

Landuse

The Worimi and Biripai Aboriginal tribes inhabited distinct, adjoining territories in the Wallis Lake district at the time of European settlement. Physical evidence of a rich Aboriginal culture includes middens, open campsites and stone artefact scatters, ceremonial grounds, and carved or otherwise scarred trees, all generally in close proximity to estuaries and swamps (Collins 2004, Gilbert 1954a,b).

Much of the Wallis Lake catchment was granted to the Australian Agricultural Company in the 1820s, although coastal areas were soon relinquished to the Crown in exchange for more suitable agricultural land further inland. Timber cutters logging Red Cedar (*Toona ciliata*) were operating in the district by the early 1830s (Gilbert 1954a).

The Wallis Lake catchment is now important for nature conservation, tourism, recreational and commercial fishing, and oyster farming (Great Lakes Council 2003). Conservation reserves include Booti Booti and Wallingat National Parks, and Coolongolook, Wallis Island and Yahoo Island Nature Reserves (Figure 1). The wetlands vary in condition from comparatively undisturbed (apart from fire) to severely modified or completely removed. Forms of wetland disturbance include agriculture, urban development, mineral sand mining on sand barriers, and drainage schemes in areas such as Darawakh, north of Tuncurry (Great Lakes Council 2007).

Previous vegetation surveys

Several earlier studies provide partial accounts of wetland vegetation within the Wallis Lake catchment, particularly saltmarsh (Coast and Wetlands Society 1985, West et al. 1985), seagrasses and mangroves (West et al. 1985), and sand barrier wetlands (Griffith et al. 2000, Griffith and Wilson 2007). Many unpublished reports, prepared for development proposals, describe wetland vegetation for specific parcels of land, although these vary in detail and methodology and are often difficult to access.

Methods

Data collection

Preliminary vegetation mapping is available for the entire Wallis Lake catchment within the Great Lakes LGA. This mapping was derived by conventional air photo interpretation (API) of 1:25 000 colour photography, although with limited field validation. The mapping is maintained in a GIS by Great Lakes Council, and distinguishes the following nine wetland groups:

(a) herbaceous wetland vegetation (e.g. sedgeland, rushland, chenopod shrubland, tussock grassland)
(b) heathland (with shrubland included)
(c) mangrove forest, woodland and shrubland
(d) swamp oak (*Casuarina glauca*) forest and woodland
(e) swamp mahogany (*Eucalyptus robusta*) forest and woodland
(f) paperbark forest and woodland dominated by *Melaleuca* species, although primarily *Melaleuca quinquenervia*
(g) paperbark – swamp oak forest and woodland
(h) swamp mahogany – swamp oak forest and woodland
(i) swamp mahogany – paperbark forest and woodland.

This catchment-wide vegetation layer formed the basis of sample site allocation, although stratification to a finer level of floristic and structural resolution was possible using alternative API mapping projects for the Frogalla and Darawakh wetlands north of Tuncurry (Griffith and Wilson 1996), and the Nabiac Pleistocene barriers south east of Nabiac (Griffith and Wilson 2007). API groups are the basic map unit of Griffith and Wilson (1996, 2007), and these are primarily distinguished by growth form and species composition in the dominant (generally tallest) stratum. When circumscribed in this manner, API groups are generally analogous to plant associations, *sensu* Beadle (1981): 'a community in which the dominant stratum exhibits uniform floristic composition, the community usually exhibiting uniform structure (also)'.

Sample sites were further stratified using GIS layers available at the time for: (a) altitude (<10, 10–20, >20 m); and (b) habitat (estuarine, alluvial, aeolian, swamp, bedrock – undifferentiated). As mapped in the GIS, bedrock included areas where transferral soil formation processes operate.

Sampling proceeded in randomly placed quadrats at 50 sites (WLC001–050) on freehold and Crown land, and quadrat size varied from 25 m^2 (in floristically and structurally simple vegetation) to 400 m^2. The majority of sites were remotely chosen and marked on aerial photographs before the fieldwork, although in a few instances vegetation types too small to be obvious on photographs were opportunistically sampled. The following data were collected for each quadrat:

(a) foliage cover (*sensu* Walker and Hopkins 1984) score for each vascular species: 1 (<1%); 2 (1–5%); 3 (6–25%); 4 (26–50%); 5 (51–75%); and 6 (76–100%)

(b) geology and soil landscape process group

(c) aspect (°)

(d) slope (°)

(e) altitude above sea level (m)

(f) topographic position (after Speight 1984) using categories for landform morphological type (e.g. closed depression, open depression, flat) and landform element (e.g. drainage depression, levee, plain, swale, swamp, tidal flat)

(g) geographic location (easting and northing)

(h) degree of exposure, determined as the azimuth (°) for each of the eight principal compass bearings (N, NE, etc.)

(i) time elapsed since last burnt (0–5 years, 5–10 years, or >10 years), determined from historical accounts or by observation of incremental post-fire branching, fire scars etc.

The WLC data are compatible with another dataset of 13 wetland quadrats for the Nabiac Pleistocene barriers (Griffith and Wilson 2007) and these data (NAB) were included in analyses. Also included were data for 13 wetland sites (BBY) in Booti Booti National Park and Yahoo Island Nature Reserve (Griffith et al. 2000). Saltmarsh data for disturbed (e.g. grazed by livestock) and undisturbed sites are available from a study by Adam et al. (1988), and 38 samples (SAL) for undisturbed vegetation were included in analyses. The BBY and SAL data sets were compiled using different foliage cover scales, and these scales were standardised to be compatible with the WLC and NAB data sets (Table 1). The location of all sites is shown in Figure 2.

Plant growth forms and vegetation structure are described according to Walker and Hopkins (1984). Species nomenclature is generally consistent with current usage at the Royal Botanic Gardens (Sydney); authorities follow Harden (1990–3, 2002) or Harden and Murray (2000). Terms for landform patterns and elements follow Speight (1984) and Murphy (2005).

Sampling focused upon transferral, alluvial, aeolian/barrier, estuarine and swamp soil landscapes. Localised wetlands may occur on other soil landscapes within the catchment, although these were not observed. Possibilities are sedgeland or forbland associated with seepage in beach soil landscapes or from exposed headlands where the landforms are colluvial, and swamp sclerophyll forest on lower bedrock hillslopes of residual soil landscapes. Seagrass vegetation was not investigated (see West et al. 1985), nor the truly aquatic (submerged) freshwater vegetation of streams and other open waters.

Data analysis

Numerical classification of sample sites was performed using PATN (Blatant Fabrications Pty Ltd 2001), to group quadrats on the basis of floristic similarity. Foliage cover scores (1 to 6) for all vascular species were analysed without further transformation. The Bray-Curtis association coefficient was employed in the analysis, in combination with the flexible UPGMA (unweighted pair group arithmetic averaging) clustering algorithm and a slightly negative (-0.1) beta value. Kent and Coker (1992) suggest that an appropriate numerical method, and hence classification, is one 'which enables a clear ecological interpretation to be made'. The Bray-Curtis coefficient was found to satisfy this requirement, and such an outcome is consistent with a view that it provides a good estimate of ecological distance, primarily because greater emphasis is placed upon similarity between common and abundant species, than upon similarity between rare species and those with low cover-abundance (Belbin 1992, 1993, Faith et al. 1987). PATN was performed on the entire set of samples irrespective of vegetation structure, and also on three subsets with samples grouped on the basis of similar vegetation structure: (1) forest and woodland; (2) shrubland and mallee; and (3) vegetation with a single stratum (e.g. heathland, sedgeland).

Trends in species richness (number of species per unit area) were examined using single-factor analysis of variance (ANOVA) and multiple comparison (Tukey-Kramer) tests. Data were log transformed where appropriate to conform to model assumptions. These analyses were performed using StatView (SAS Institute Inc. 1999).

Results

The wetland vegetation of Wallis Lake catchment displays considerable structural and floristic variation. A total of 393 vascular plant taxa were recorded in quadrats, and approximately 10% of these are exotic (Appendix 1). Based on PATN analyses (Figures 3–5), sample sites have been grouped by formation (e.g. forest and woodland) and subformation (e.g. swamp sclerophyll forest and woodland) into the following vegetation units with accompanying details of composition and habitat. Equivalent API groups (map units) are provided from Griffith and Wilson (1996, 2007) or related mapping projects elsewhere in coastal northern NSW (e.g. Griffith et al. 2003).

Wetland vegetation descriptions

Mangrove forest and woodland (MF/W), grading into mangrove shrubland (MS)

Structure: low to mid-high, open woodland to open forest (grading into tall to very tall, sparse to closed shrubland).

Floristic composition: *Avicennia marina* subsp. *australasica* dominates the tallest stratum. *Aegiceras corniculatum* may be present as an understorey, particularly where the tallest stratum is diffuse. The immediate ground surface is generally unvegetated except for pneumatophores, although saltmarsh species such as *Sporobolus virginicus* or *Juncus kraussii* subsp. *australiensis* can occupy gaps in the tallest stratum, particularly where the ground surface is slightly elevated.

Table 1. Foliage cover standardised to a 6-point scale for different data sets.

Score	NAB (Griffith & Wilson 2007) and WLC (this study)	BBY (Griffith et al. 2000)	SAL (Adam et al. 1988)
1	<1%	<5%; uncommon	<4% & very rare; <4% & scattered
2	1–5%	<5%; common	<4% & frequent
3	6–25%	6–20%	4–10%; 10–25%
4	26–50%	21–50%	25–33%; 33–50%
5	51–75%	51–75%	50–75%
6	76–100%	76–100%	75–90%; 90–100%

Notes:

1. Walker and Hopkins (1984) define foliage cover as 'the percentage of the sample site occupied by the vertical projection of foliage and branches', and this definition was applied when collecting the BBY, NAB and WLC data. The 10-point Domin cover-abundance scale as used by Adam et al. (1988) defines cover in a comparable manner (see Kent and Coker 1992).
2. The cover classes used by Griffith and Wilson (2007) follow the Braun-Blanquet scale, and this scale was applied when collecting the WLC data. The NSW Department of Environment and Climate Change has adopted a modified Braun-Blanquet scale, as used in Griffith et al. (2000).

Habitat and community relations: Found on intertidal flats (Figure 3). Saltmarsh vegetation generally replaces mangroves at slightly higher elevations.

Sample sites: BBY006, WLC018.

API groups: *Avicennia marina* subsp. *australasica* MF/W; *Avicennia marina* subsp. *australasica* MS.

Swamp sclerophyll forest and woodland (SSF/W)

Structure: (occasionally low to) mid-high to very tall, open woodland to closed forest.

Floristic composition: Many stands of SSF or SSW have a tallest stratum that is clearly dominated by one of the species *Eucalyptus robusta* (e.g. WLC019, WLC027), *Melaleuca quinquenervia* (e.g. NAB018, WLC021) or *Casuarina glauca* (e.g. WLC005, WLC030); although stands dominated by two of these species are not uncommon, typically of *Melaleuca quinquenervia* and *Casuarina glauca* (e.g. WLC023, WLC033) or *Melaleuca quinquenervia* and *Eucalyptus robusta* (e.g. WLC043, WLC024). Other locally subsidiary or co-dominant tallest stratum species with *Casuarina glauca*, *Eucalyptus robusta* or *Melaleuca quinquenervia* include *Eucalyptus grandis* (e.g. WLC049), *Eucalyptus resinifera* (WLC040), *Eucalyptus tereticornis* (e.g. WLC015) and *Livistona australis* (e.g. WLC032). *Melaleuca linariifolia* (WLC009) or *Melaleuca nodosa* (WLC029) also form limited areas of low to tall SSF. Understorey composition (Figure 3) varies in response to site differences in soil type, extent of waterlogging and water chemistry, and management (e.g. fire and livestock grazing). The saltmarsh species *Baumea juncea*, *Juncus kraussii* subsp. *australiensis* or *Sporobolus virginicus* are common dominants where there is a tidal influence, while the presence of *Phragmites australis* indicates probable brackish conditions. Likely species on sand barriers and associated flats include *Baloskion tetraphyllum* subsp. *meiostachyum*, *Blechnum indicum*, *Empodisma minus*, *Gleichenia microphylla*, *Leptocarpus tenax*, *Pteridium esculentum* and *Schoenus brevifolius*, sometimes with *Melaleuca sieberi* forming a distinct second tree stratum (e.g. NAB019). On extratidal plains (former estuaries) and associated alluvial landforms (e.g. backplains, levee toes) the understorey is diverse, although characteristic species include *Entolasia marginata*, *Gahnia clarkei*, *Hypolepis muelleri*, *Imperata cylindrica* var. *major*, *Ischaemum australe*, *Livistona australis* and *Melaleuca linariifolia*. *Entolasia stricta*, *Imperata cylindrica* var. *major*, *Lepidosperma neesii*, *Lepidosperma quadrangulatum* and many other species occupy the understorey of *Melaleuca nodosa* SSF on broad transferral drainage plains, whereas an understorey of *Gahnia clarkei* and various rainforest species was observed along transferral drainage depressions.

Habitat and community relations: Occupies open depressions (e.g. swales, drainage depressions) and poorly drained flats or plains. Also borders closed depressions (swamps) where standing water accumulates (Figure 3). Widespread on Quaternary sediments of estuarine and aeolian/barrier soil landscapes. Also associated with alluvial landscapes (e.g. backplains), and transferral drainage depressions and drainage plains deposited below bedrock hillslopes. Wet or dry sclerophyll forest and woodland often replaces the swamp subformations as soil drainage improves, although boundaries between the different subformations may be diffuse in areas of minimal relief (e.g. intergradation of *Eucalyptus grandis* WSF and *Melaleuca quinquenervia* SSF).

Sample sites:

BBY006, BBY023, BBY043, BBY046, BBY048, NAB018, NAB019, NAB026, WLC005, WLC006, WLC009, WLC011, WLC012, WLC013, WLC014, WLC015, WLC016, WLC017, WLC018, WLC019, WLC020, WLC021, WLC023, WLC024, WLC027, WLC028, WLC029, WLC030, WLC031, WLC032, WLC033, WLC034, WLC036, WLC037, WLC038, WLC039, WLC040, WLC041, WLC042, WLC043, WLC044, WLC045, WLC047, WLC048, WLC049.

API groups: *Eucalyptus robusta* SSF/W, *Melaleuca quinquenervia* SSF/W, *Casuarina glauca* SSF/W, *Melaleuca quinquenervia* – *Casuarina glauca* SSF/W, *Eucalyptus robusta* – *Melaleuca quinquenervia* SSF/W, *Eucalyptus robusta* – *Melaleuca sieberi* SSF/W, *Melaleuca quinquenervia* – *Livistona australis* SSF, *Melaleuca linariifolia* SSF and *Melaleuca nodosa* SSF are already mapped for parts of the catchment (Griffith and Wilson 1996, 2007). Others that may be present include *Eucalyptus resinifera* – *Eucalyptus robusta* – *Angophora costata* SSF/W and *Melaleuca quinquenervia* – *Eucalyptus tereticornis* SSF/W.

Swamp sclerophyll mallee woodland (SSMW)

Structure: very tall to extremely tall, mallee woodland and open mallee woodland.

Floristic composition: *Eucalyptus robusta* dominates the tallest stratum. Understorey species include *Baloskion tetraphyllum* subsp. *meiostachyum*, *Dianella caerulea*, *Imperata cylindrica* var. *major* and *Leptospermum polygalifolium* subsp. *cismontanum*.

Habitat and community relations: Found in open depressions associated with beach ridges and dunes (Figure 4), where a shallow watertable periodically rises to the ground surface. Often replaced upslope by dry sclerophyll shrubland or dry heathland.

Sample sites: BBY044.

API group: *Eucalyptus robusta* SSMW.

Swamp sclerophyll shrubland (SSS)

Structure: tall to very tall, sparse to closed shrubland.

Floristic composition: The tallest stratum is dominated by *Banksia ericifolia* subsp. *macrantha* (NAB015, NAB022), *Melaleuca ericifolia* (WLC008, WLC022), *Melaleuca quinquenervia* (BBY045) or *Melaleuca sieberi* (NAB010, NAB011). Understorey composition varies with site differences in soil type, extent of waterlogging and water chemistry, and the fire regime. Likely understorey species in *Banksia ericifolia* subsp. *macrantha* SSS include *Banksia oblongifolia*, *Eurychorda complanata*, *Lepidosperma filiforme*, *Leptospermum liversidgei* and *Xanthorrhoea fulva*. The understorey of *Melaleuca sieberi* SSS includes *Banksia oblongifolia*, *Leptocarpus tenax*, *Leptospermum arachnoides*, *Melaleuca thymifolia* and *Ptilothrix deusta*. *Melaleuca ericifolia* SSS supports an understorey of *Baumea juncea*, *Hemarthria uncinata*, *Ischaemum australe*, *Leptocarpus tenax* and other species, whereas *Baumea articulata*, *Baumea juncea* and *Juncus kraussii* subsp. *australiensis* are some of the species recorded in *Melaleuca quinquenervia* SSS.

Habitat and community relations: Generally associated with poorly drained open depressions (e.g. swales) and flats where a shallow watertable periodically rises to the ground surface, although also extends into closed depressions (swamps) where standing water accumulates (Figure 4). Swamp sclerophyll shrubland may grade into wet heathland, with boundaries between the two formations influenced in part by fire. It often adjoins swamp sclerophyll forest and woodland or, where soils are comparatively well drained, dry sclerophyll forest and woodland.

Sample sites: BBY045, NAB010, NAB011, NAB015, NAB022, WLC008, WLC022.

API groups: *Banksia ericifolia* subsp. *macrantha* SSS; *Melaleuca ericifolia* SSS; *Melaleuca quinquenervia* SSS; *Melaleuca sieberi* SSS.

Wet heathland (WH)

Structure: mid-high to tall closed heathland.

Floristic composition: This subformation is floristically variable. In swales, few to several of the heath shrubs *Banksia ericifolia* subsp. *macrantha*, *Banksia oblongifolia*, *Boronia falcifolia*, *Dillwynia floribunda*, *Epacris microphylla* var. *microphylla*, *Leptospermum liversidgei*, *Sprengelia* spp. and *Xanthorrhoea fulva*, and the sedges

Empodisma minus, *Gahnia sieberiana*, *Schoenus scabripes* and *Sporadanthus interruptus* are subsidiary to co-dominant in locally variable combinations. On flats the heath shrubs *Banksia oblongifolia*, *Hakea teretifolia* subsp. *teretifolia*, *Leptospermum arachnoides* and *Xanthorrhoea fulva* are locally co-dominant or subsidiary in varying combinations, along with one or more sedges (*Lepidosperma neesii*, *Leptocarpus tenax*, *Ptilothrix deusta*). Some of the heterogeneity in floristic composition may be attributed to fire, where frequent burning limits recruitment of seeders (e.g. *Banksia ericifolia* subsp. *macrantha*, *Dillwynia floribunda*, *Hakea teretifolia* subsp. *teretifolia*, *Leptospermum arachnoides*, *Sprengelia* spp.).

Habitat and community relations: Characteristic of poorly drained sand barrier swales (open depressions) and associated flats with a shallow watertable (Figure 5). In the absence of fire for extended periods, *Banksia ericifolia* subsp. *macrantha* may overtop shorter species to dominate as swamp sclerophyll shrubland. Wet heathland is replaced by sedgeland where soil waterlogging is more severe.

Sample sites: BBY019, NAB003, NAB004, NAB005, NAB014, WLC050.

API groups: *Banksia oblongifolia – Leptospermum liversidgei – Sporadanthus interruptus – Sprengelia* spp. *– Xanthorrhoea fulva* WH; *Banksia oblongifolia – Hakea teretifolia* subsp. *teretifolia – Ptilothrix deusta – Xanthorrhoea fulva* WH.

Chenopod shrubland (CS) and tussock grassland (TG)

Structure: dwarf to low, open to closed chenopod shrubland; low to mid-high, open to closed tussock grassland.

Floristic composition: Chenopod shrublands are generally dominated by *Sarcocornia quinqueflora* subsp. *quinqueflora* (eg. SAL832, SAL833), sometimes with the forb *Triglochin striatum* also abundant (eg. SAL854, SAL859). Another chenopod shrub, *Suaeda australis*, is a less frequent dominant (SAL926). Tussock grassland is dominated by *Sporobolus virginicus* (eg. SAL853, SAL855), although in places this species is more-or-less co-dominant with *Sarcocornia quinqueflora* subsp. *quinqueflora* (e.g. SAL834, SAL851).

Habitat and community relations: This is the characteristic saltmarsh vegetation on tidal flats (Figure 5). It generally occurs immediately upslope of mangroves although seaward of *Juncus kraussii* subsp. *australiensis* rushland.

Sample sites: BBY004, SAL832, SAL833, SAL834, SAL837, SAL851, SAL853, SAL854, SAL855, SAL856, SAL858, SAL859, SAL860, SAL863, SAL864, SAL902, SAL903, SAL904, SAL906, SAL910, SAL926.

API group: *Sarcocornia quinqueflora* subsp. *quinqueflora – Sporobolus virginicus* CS/TG, mapped as a community complex due to limits of scale; none assigned for *Suaeda australis* CS.

Sedgeland (S)

Structure: mid-high to very tall closed sedgeland.

Floristic composition: Many sedgelands can be distinguished by the presence of one species as the tallest dominant, and in the Wallis Lake catchment this is the case for the following: *Baumea articulata* (NAB002, WLC004); *Baumea juncea* (eg. BBY005, SAL840); *Bolboschoenus caldwellii* (SAL913); *Eleocharis equisetina* (WLC002); *Eleocharis sphacelata* (WLC010); *Lepironia articulata* (WLC025); and *Schoenoplectus subulatus* (SAL909). Another floristically diverse sedgeland is distinguished for shallow swamps associated with beach ridge barriers and dunefields. Locally variable combinations of the sedges *Baloskion pallens*, *Baumea arthrophylla*, *Baumea teretifolia*, *Chorizandra sphaerocephala*, *Lepidosperma limicola*, *Leptocarpus tenax* and *Schoenus brevifolius* are likely in these shallow swamps, along with certain heath shrubs (e.g. *Callistemon pachyphyllus*, *Melaleuca thymifolia*).

Habitat and community relations: *Baumea juncea* sedgeland occupies supratidal flats, and sedgelands of *Bolboschoenus caldwellii* or *Schoenoplectus subulatus* occur in the upper reaches of saltmarsh (Figure 5) where conditions are likely to be brackish (Adam et al. 1988). The remaining sedgelands are more typical of closed depressions containing freshwater, although for some species (e.g. *Baloskion pallens*, *Lepironia articulata*, *Schoenus brevifolius*) this water can be acidic. Sedgeland is often replaced by wet heathland, swamp sclerophyll shrubland or swamp sclerophyll forest and woodland as drainage improves.

Sample sites: BBY002, BBY005, NAB002, NAB007, WLC002, WLC004, WLC010, WLC025, WLC026, SAL840, SAL870, SAL909, SAL913, SAL925.

API groups: *Baumea articulata* S; *Baumea juncea* S; *Bolboschoenus caldwellii* S; *Eleocharis equisetina* S; *Eleocharis sphacelata* S; *Lepironia articulata* S; *Schoenoplectus subulatus* S; *Leptocarpus tenax – Baloskion pallens – Schoenus brevifolius* S.

Rushland (R)

Structure: tall to very tall, open to closed rushland.

Floristic composition: Rushlands are distinguished by the presence of one species as the tallest dominant, and in the Wallis Lake catchment this is the case for *Juncus kraussii* subsp. *australiensis* (eg. BBY003, SAL836), *Phragmites australis* (eg. BBY026, WLC007) and *Typha domingensis* (WLC035). Adam et al. (1988) further classify *Juncus kraussii* subsp. *australiensis* rushlands to recognise shorter species that are nonetheless abundant in some stands (e.g. *Samolus repens*, *Sporobolus virginicus*).

Habitat and community relations: Rushlands dominated by *Juncus kraussii* subsp. *australiensis* or *Phragmites australis* generally occupy upper tidal to supratidal flats (Figure 5), or depressions where conditions are likely to be brackish (Adam et al. 1988). *Typha domingensis* rushland was observed close to an estuary, although where the drainage had been modified following the construction of an embankment and road, resulting in ponding.

Sample sites: BBY003, WLC007, WLC035, WLC046, SAL838, SAL868, BBY026, SAL905, SAL836, SAL845, SAL848, SAL852, SAL846, SAL850, SAL865, SAL867, SAL907, SAL908.

API groups: *Juncus kraussii* subsp. *australiensis* R; *Phragmites australis* R; *Typha domingensis* R.

Sod grassland (SG)

Structure: tall to extremely tall sod grassland and closed sod grassland.

Floristic composition: *Paspalum distichum* dominates, although *Eleocharis equisetina* may be present as a scattered emergent.

Habitat and community relations: Fringes freshwater swamps supporting *Eleocharis equisetina* sedgeland (Figure 5).

Sample sites: WLC003.

API group: none assigned, although *Paspalum distichum* SG reported for the NSW North Coast in other studies (e.g. Pressey 1981, 1987a,b, Pressey and Griffith 1987).

Plant – environment relationships

Site data analyses using PATN provide insights into the floristic and environmental relationships of wetlands in the Wallis Lake catchment (Figures 3–6). PATN optimised the number of floristic groups for each analysis at a single fusion (similarity) level (e.g. groups 1–7 in Figure 3), although there is no reason why floristic groups cannot be distinguished at different levels of similarity (e.g. groups

1. **Deep freshwater swamp:** *Melaleuca quinquenervia* SSF with *Baumea articulata* in understorey.
2. **Sand barrier open depressions and associated flats:** *Eucalyptus robusta* SSF/W and *E. robusta – Melaleuca quinquenervia* SSF/W, with *Baloskion tetraphyllum* subsp. *meiostachyum, Empodisma minus, Gleichenia microphylla* etc. in understorey.

3a. **Extratidal plains (former estuaries) and associated alluvial landforms (e.g. backplains, levee toes):** SSF (occasionally SSW) dominated by *Casuarina glauca, Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations, with *Eucalyptus grandis, E. resinifera, E. tereticornis* or *Livistona australis* sometimes subsidiary to co-dominant; also localised *Melaleuca linariifolia* SSF; understorey of *Entolasia marginata, Gahnia clarkei, Hypolepis muelleri, Imperata cylindrica* var. *major, Ischaemum australe, Melaleuca linariifolia* and many others.

3b. **Extratidal plains (former estuaries) with inferred residual soil salinity:** SSF/W dominated by *Casuarina glauca, Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations, with *Baumea juncea, Gahnia clarkei, Imperata cylindrica* var. *major* etc. in understorey.

3c. **Transferral drainage depression (merging downslope with an extratidal plain):** *Casuarina glauca – Eucalyptus robusta – Livistona australis* SSF with *Gahnia clarkei* and rainforest species in understorey.

4. **Transferral drainage plain:** *Melaleuca nodosa* SSF with *Entolasia stricta, Lepidosperma neesii, L. quadrangulatum* etc. in understorey.
5. **Brackish to upper tidal flats of contemporary estuary:** *Casuarina glauca* SSF and *C. glauca – Melaleuca quinquenervia* SSF/W with *Baumea juncea, uncus kraussii* subsp. *australiensis, Phragmites australis, Sporobolus virginicus* etc. in understorey.
6. **Prior stream channels associated with supratidal flats:** *Casuarina glauca* SSF/W with *Alocasia brisbanensis, Hypolepis muelleri, Melaleuca styphelioides, Myoporum acuminatum* etc. in understorey.
7. **Intertidal flats:** *Avicennia marina* subsp. *australasica* MF/W.

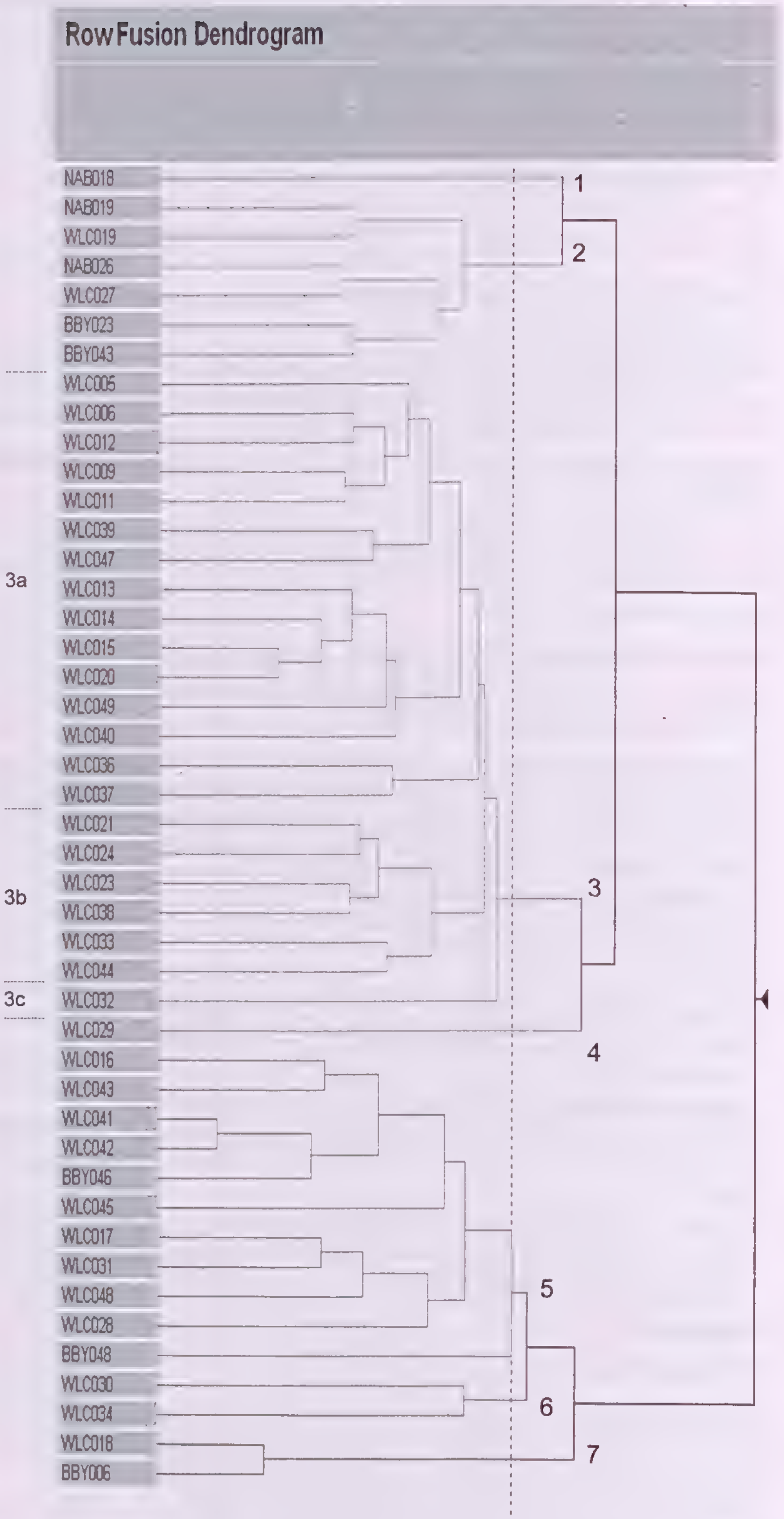


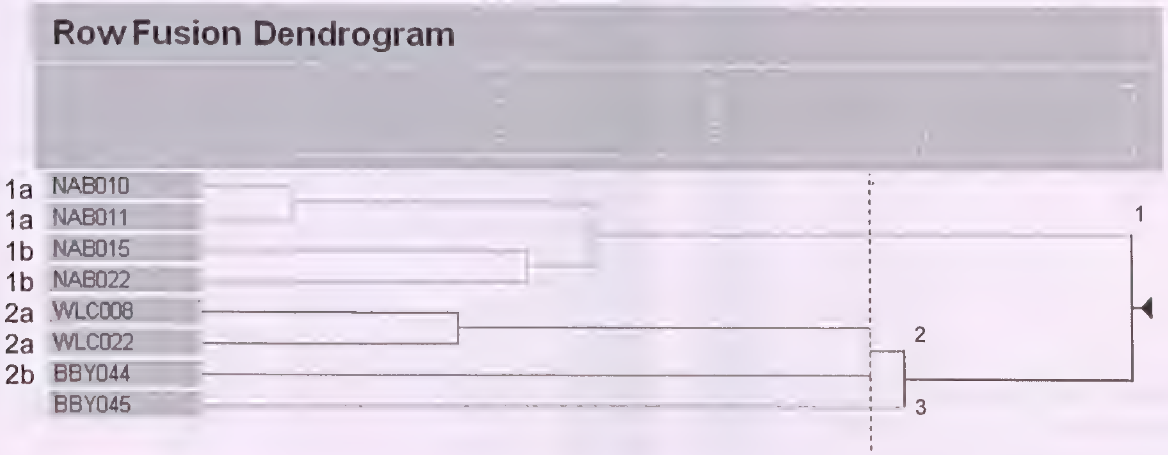
Fig. 3. Floristic classification of sites in swamp sclerophyll forest and woodland (SSF/W), and mangrove forest and woodland (MF/W).

3a–c in Figure 3) where such groups make 'ecological sense' (Kent and Coker 1992). Analyses were performed for 112 quadrats (Appendix 1). Two additional quadrats (WLC001 and WLC035) inadvertently placed in habitats with severe localised disturbance were omitted to avoid confounding the interpretation of relationships to soil landscape processes.

Wetland forests and woodlands have a tallest stratum that is primarily dominated by *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations (Figure 3). Nonetheless, floristic composition in the understorey is variable, and this variation aligns with differences in soil landscape and hydrology. For example, the swamp sclerophyll forests and woodlands on sand barriers (group 2) and extratidal plains of former estuaries (group 3) are floristically distinct even though both habitats support *Eucalyptus robusta* and *Melaleuca quinquenervia* as dominant species in the tallest stratum. Floristic differences are also apparent between stands of *Casuarina glauca* associated with former or contemporary estuaries (group 3 cf. group 5). Similar relationships between floristic composition, hydrology and landscape are apparent for shrubland and mallee woodland (Figure 4), and also for wetland vegetation with a single stratum (Figure 5). Examples for single-stratum vegetation are the floristic differences between vegetation associated with sand barriers (groups 5 and 6) and tidal flats (groups 7 and 8), and also the differences within sand barrier landscapes according to the extent of waterlogging (group 5 cf. group 6).

Relationships between floristic composition, soil landscape and hydrology remain apparent in an analysis of all sample sites irrespective of vegetation structure (Figure 6). This analysis also highlights overlap between vegetation structure and floristic composition, for example between wet heathland and swamp sclerophyll shrubland on sand barriers (group 9) where the latter supports an understorey of wet heathland species. Floristic overlap is also apparent between swamp sclerophyll forest, woodland and shrubland on extratidal plains (group 8c). Nonetheless, in some habitats vegetation formations comprising a single stratum remain floristically distinct from forests, woodlands and other multi-stratum vegetation (e.g. groups 2, 3 and 11 in Figure 6). *Melaleuca nodosa* swamp sclerophyll forest on a transferral drainage plain remained floristically distinct in the analysis of forest and woodland sites only (group 4 in Figure 3), and also in the analysis of all sites irrespective of structure (group 7 in Figure 6). Another site in swamp sclerophyll forest along a transferral drainage depression also remained comparatively distinct in relation to floristic composition of the understorey (group 3c in Figure 3; group 8b in Figure 6).

It is apparent that tree species such as *Melaleuca quinquenervia* tolerate a range of environmental conditions (Figure 3). This also seems to be the case for herbaceous species such as *Phragmites australis* and *Baumea juncea*. *Phragmites australis* forms a rushland in habitats that are likely to vary in salinity (groups 3 and 4 in Figure 5). *Baumea juncea* forms a sedgeland on supratidal flats (group 4 in Figure 5), although it is also locally conspicuous in the understorey of swamp sclerophyll forest or woodland in a range of habitats (e.g. groups 2, 3b and 5 in Figure 3; Appendix 1). Adam et al. (1988) noted an apparently wide range of ecological tolerance in both species.



1a. Sand barrier flats: *Melaleuca sieberi* SSS.
1b. Sand barrier swales: *Banksia ericifolia* subsp. *macrantha* SSS.
2a. Extratidal plains (former estuaries) with inferred residual soil salinity: *Melaleuca ericifolia* SSS.
2b. Sand barrier drainage depression: *Eucalyptus robusta* SSMW.
3. Brackish swamp: *Melaleuca quinquenervia* SSS.

Fig. 4. Floristic classification of sites in swamp sclerophyll shrubland (SSS) and swamp sclerophyll mallee woodland (SSMW).

1. **Deep freshwater swamps:** *Baumea articulata* S and *Eleocharis sphacelata* S.
2. **Shallow freshwater swamps:** *Eleocharis equisetina* S and *Paspalum distichum* SG.
3. **Brackish depressions and flats near estuary:** *Phragmites australis* R, *Bolboschoenus caldwellii* S and *Schoenoplectus subulatus* S.
4. **Supratidal flats:** *Phragmites australis* R, *Baumea juncea* S and *Suaeda australis* CS.
5. **Sand barrier swales and associated flats:** WH of *Banksia oblongifolia*, *Hakea teretifolia* subsp. *teretifolia*, *Leptospermum liversidgei*, *Xanthorrhoea fulva* etc.
6. **Sand barrier acid swamps:** *Baloskion pallens – Leptocarpus tenax – Schoenus brevifolius* etc. S and *Lepironia articulata* S.
7. **Upper tidal flats:** *Juncus kraussii* subsp. *australiensis* R and *Sporobolus virginicus* TG.
8. **Lower tidal flats:** *Sarcocornia quinqueflora* subsp. *quinqueflora* CS and *S. quinqueflora* subsp. *quinqueflora – Sporobolus virginicus* CS/TG.

Note: two sites (BBY004 and SAL910) placed in group 7 by PATN are somewhat intermediate in floristic composition with sites in group 8. Their placement in group 7 may be a reflection of comparatively low foliage cover scores due to the presence on unvegetated ground within the quadrats.

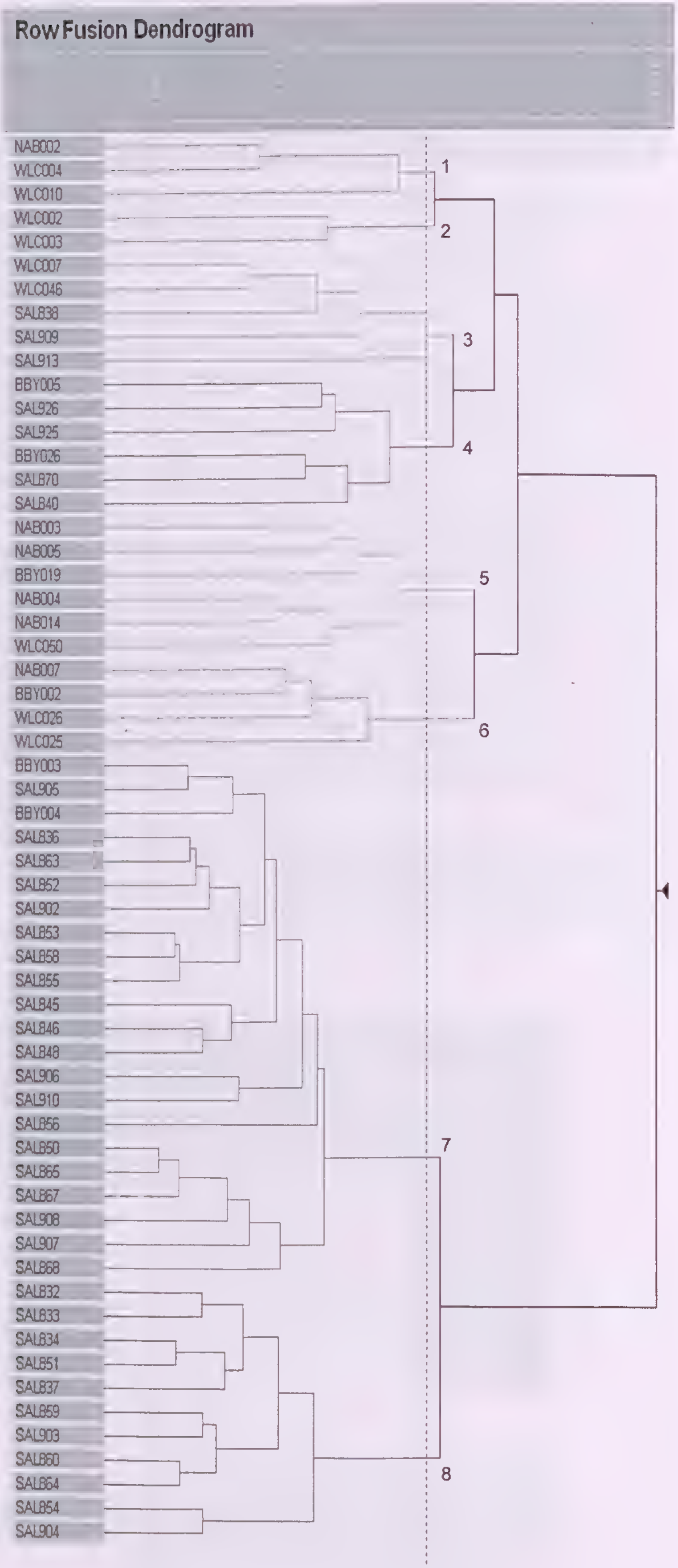


Fig. 5. Floristic classification of sites in vegetation with a single stratum.

CS: chenopod shrubland; R: rushland; S: sedgeland; SG: sod grassland; TG: tussock grassland; WH: wet heathland.

1. **Freshwater to brackish swamps:** *Melaleuca quinquenervia* SSF and *M. quinquenervia* SSS with *Baumea articulata* etc. in understorey; *Baumea articulata* S.
2. **Freshwater swamps:** *Eleocharis equisetina* S; *E. sphacelata* S; *Paspalum distichum* SG.
3. **Sand barrier acid swamps:** *Baloskion pallens – Leptocarpus tenax – Schoenus brevifolius* etc. S; *Lepironia articulata* S.
4. **Brackish depressions and flats near estuary:** *Melaleuca quinquenervia – Casuarina glauca* SSF/W with *Phragmites australis* in understorey; *Phragmites australis* R; *Bolboschoenus caldwellii* S; *Schoenoplectus subulatus* S.
5. **Supratidal flats and associated prior stream channels:** *Casuarina glauca* SSF/W, generally with *Phragmites australis* and/or *Baumea juncea* in understorey; *Phragmites australis* R; *Baumea juncea* S; *Suaeda australis* CS.
6. **Sand barrier open depressions and associated flats:** *Eucalyptus robusta* SSF/W, *E. robusta – Melaleuca quinquenervia* SSF/W and *E. robusta* SSMW with *Baloskion tetraphyllum* subsp. *meiostachyum, Empodisma minus, Gleichenia microphylla* etc. in understorey.
7. **Transferral drainage plain:** *Melaleuca nodosa* SSF with *Entolasia stricta, Lepidosperma neesii, L. quadrangulatum* etc. in understorey.

8a. **Extratidal plains (former estuaries) and associated alluvial landforms (e.g. backplains, levee toes):** SSF (occasionally SSW) dominated by *Casuarina glauca, Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations, with *Eucalyptus grandis, E. resinifera, E. tereticornis* or *Livistona australis* sometimes subsidiary to co-dominant; also localised *Melaleuca linariifolia* SSF; understorey of *Entolasia marginata, Gahnia clarkei, Hypolepis muelleri, Imperata cylindrica* var. *major, Ischaemum australe, Melaleuca linariifolia* and many others.

8b. **Transferral drainage depression (merging downslope with an extratidal plain):** *Casuarina glauca – Eucalyptus robusta – Livistona australis* SSF with *Gahnia clarkei* and rainforest species in understorey.

8c. **Extratidal plains (former estuaries) with inferred residual soil salinity:** SSF/W dominated by *Casuarina glauca, Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations, with *Baumea juncea, Gahnia clarkei, Imperata cylindrica* var. *major* etc. in understorey; *Melaleuca ericifolia* SSS with similar understorey.

9. **Sand barrier swales and associated flats:** WH of *Banksia oblongifolia, Hakea teretifolia* subsp. *teretifolia, Leptospermum liversidgei, Xanthorrhoea fulva* etc; *Banksia ericifolia* subsp. *macrantha* SSS and *Melaleuca sieberi* SSS with WH species in understorey.

10a. **Upper tidal flats:** *Casuarina glauca* SSF/W with *Juncus kraussii* subsp. *australiensis, Sporobolus virginicus* in understorey; *Juncus kraussii* subsp. *australiensis* R; *Sporobolus virginicus* TG.

10b. **Intertidal flats:** *Avicennia marina* subsp. *australasica* MF/W, sometimes with *Juncus kraussii* subsp. *australiensis, Sporobolus virginicus* in understorey.

11. **Lower tidal flats:** *Sarcocornia quinqueflora* subsp. *quinqueflora* CS; *S. quinqueflora* subsp. *quinqueflora – Sporobolus virginicus* CS/TG.

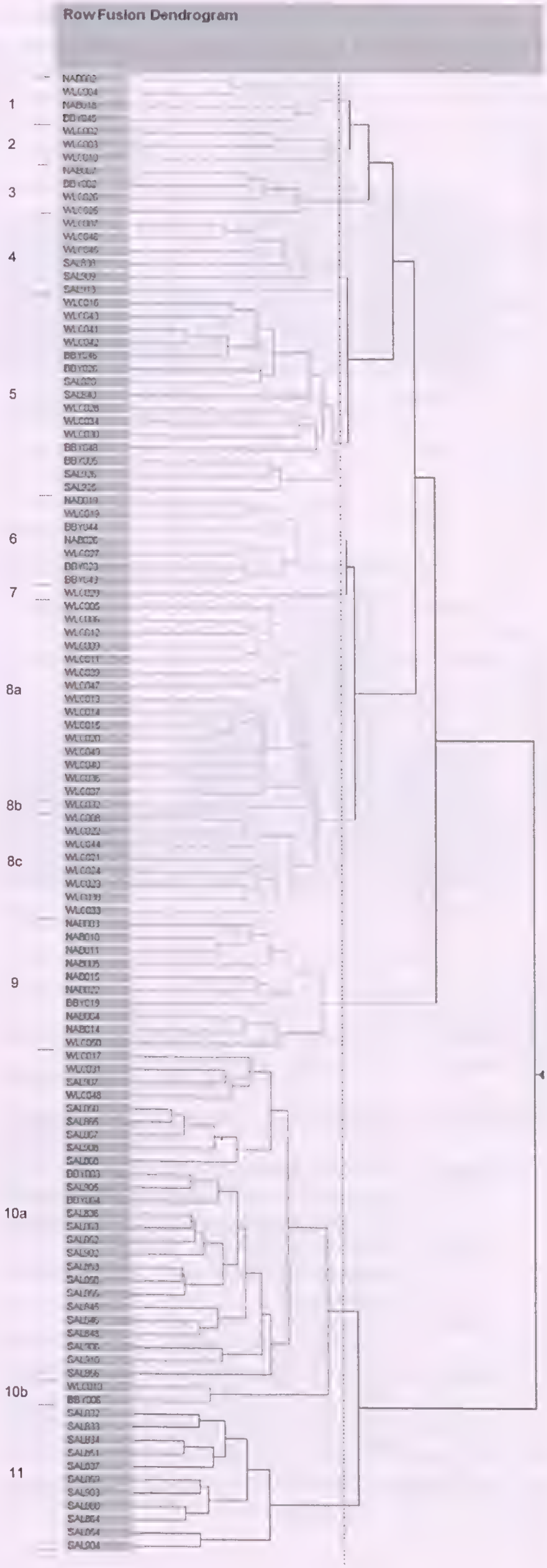


Fig. 6. Floristic classification of all wetland sites in Wallis Lake catchment.

CS: chenopod shrubland; MF/W: mangrove forest/woodland; R: rushland; S: sedgeland; SG: sod grassland; SSF/W: swamp sclerophyll forest/woodland; SSMW: swamp sclerophyll mallee woodland; SSS: swamp sclerophyll shrubland; TG: tussock grassland; WH: wet heathland.

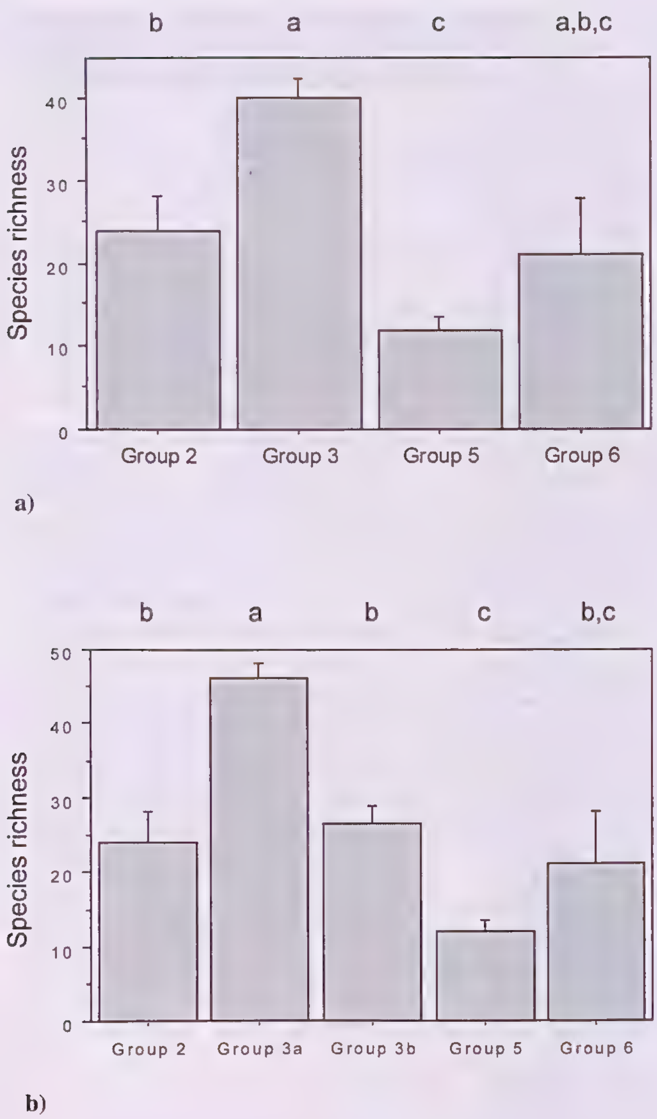


Fig. 7. Mean (+/- s.e.) species richness of native vascular plants in 400 m^2 quadrats for swamp sclerophyll forest and woodland.

Group 2:	Sand barrier open depressions and associated flats.
Group 3:	Extratidal plains (former estuaries), and associated alluvial landforms (e.g. backplains, levee toes) and transferral drainage depressions.
Group 3a:	Extratidal plains (former estuaries) and associated alluvial landforms (e.g. backplains, levee toes).
Group 3b:	Extratidal plains (former estuaries) with inferred residual soil salinity.
Group 5:	Brackish to upper tidal flats of contemporary estuary.
Group 6:	Prior stream channels associated with supratidal flats.

Significant differences (ANOVA: $P < 0.0001$; Tukey-Kramer: $P < 0.05$) are denoted with different letters.

Species richness in swamp sclerophyll forest and woodland

Species richness data for quadrats of uniform size (400 m^2) allowed a comparison of samples in swamp sclerophyll forest and woodland (quadrat size was either variable or unknown for samples in other vegetation formations). The mean species richness of native vascular plants (Figure 7a) was found to be significantly higher for swamp sclerophyll forest and woodland samples comprising floristic group 3 in Figure 3. These forests and woodlands occur on extratidal plains (former estuaries) and associated alluvial landforms (e.g. backplains, levee toes), and also along transferral drainage depressions. This trend of significantly higher mean species richness was even stronger for group 3a in Figure 3 when samples for extratidal plains with likely residual soil salinity (group 3b) were isolated (Figure 7b). In comparison, swamp sclerophyll forest and woodland associated with brackish to tidal flats of the contemporary estuary displayed the lowest mean species richness (group 5 in Figure 7a,b). This floristic group has a tallest stratum characteristically dominated by *Casuarina glauca*, with *Baumea juncea*, *Juncus kraussii* subsp. *australiensis* and *Phragmites australis* some of the likely understorey species.

The high species richness for native plants in swamp sclerophyll forests and woodlands on extratidal plains and associated alluvial and transferral landforms is a reflection of diversity in the understorey, particularly for the ground stratum which supports a variety of grasses, sedges, ferns and forbs. Unfortunately, extratidal plains and associated landforms also support a larger number of weeds. For example, the mean number of exotics per quadrat was 5.0 for floristic group 3a (Figure 3) although only 1.6 for group 5 on flats of the contemporary estuary, and weeds were absent from quadrats for group 2 on sand barriers.

Species of national or regional conservation significance

The present survey did not specifically target wetland plants of high conservation value, and records were largely incidental during the collection of site data. Species of known or potential conservation significance are outlined below. Three species (*Asperula asthenes*, *Lindernia alsinoides*, *Maundia triglochinoides*) are formally listed under the NSW *TSC Act*, and two (*Asperula asthenes*, *Gonocarpus salsoloides*) are *Rare or Threatened Australian Plants* (ROTAP) (Briggs and Leigh 1996). The remaining species are likely to be at least regionally significant.

Blechnum camfieldii **(Blechnaceae)**

Endemic to south-eastern Queensland and coastal NSW; reported to be locally extinct in places due to habitat destruction and therefore rare and possibly endangered (Chambers and Farrant 1998).

Recorded in *Eucalyptus robusta* (+/- *Melaleuca quinquenervia*) swamp sclerophyll forest and woodland (WLC024, WLC027).

Bolboschoenus caldwellii (Cyperaceae)

Occasional in swamps (Harden 1993); PlantNET has few records north of Wallis Lake on the NSW North Coast.

Dominates sedgeland (SAL913), and present in *Phragmites australis* rushland (SAL838).

Carex lobolepis (Cyperaceae)

PlantNET has no other records for coastal lowlands in NSW.

Recorded in *Casuarina glauca* swamp sclerophyll forest (WLC047).

Isolepis producta (Cyperaceae)

PlantNET has no other records for the NSW North Coast.

Recorded for Frogalla Swamp (452000 6449250) in 1996 during vegetation mapping by S. Griffith and R. Wilson.

Lepidosperma limicola (Cyperaceae)

Apparently absent from much of coastal NSW to the north of Wallis Lake; PlantNET has few records for the North Coast generally.

Recorded in wet heathland (NAB004, NAB014) and *Melaleuca sieberi* swamp sclerophyll shrubland (NAB010).

Schoenoplectus subulatus (Cyperaceae)

The distribution is scattered (Harden 1993); PlantNet has few records for the NSW North Coast.

Dominates sedgeland (SAL909). Also in *Baumea juncea* sedgeland (SAL925) and *Melaleuca quinquenervia* swamp sclerophyll shrubland (BBY045).

Schoenus scabripes (Cyperaceae)

Apart from a disjunct occurrence on the NSW South Coast (PlantNET), extends north from the Forster district.

Recorded in wet heathland (NAB004).

Maundia triglochinoides (Juncaginaceae)

Listed as Vulnerable under the NSW *TSC Act.*

Recorded in *Melaleuca quinquenervia* swamp sclerophyll forest (NAB018).

Deyeuxia quadriseta (Poaceae)

PlantNET has few records for the NSW North Coast.

Recorded in *Melaleuca quinquenervia* swamp sclerophyll forest (WLC038).

Poa poiformis var. *poiformis* (Poaceae)

Records for Yahoo Island NR in Wallis Lake and Kattang NR near Laurieton represent apparent outliers from the main distribution, which extends southwards from Port Stephens (Griffith et al. 2000, PlantNET).

Recorded in *Casuarina glauca* swamp sclerophyll forest or woodland on Yahoo Island (Griffith et al. 2000).

Hydrocotyle pterocarpa (Apiaceae)

Apparently uncommon in NSW, and on the North Coast known only from the Wallis Lake catchment (PlantNET).

Recorded in *Eucalyptus robusta* swamp sclerophyll woodland (WLC027).

Lilaeopsis polyantha (Apiaceae)

PlantNET has few records for the NSW North Coast.

Recorded in *Melaleuca quinquenervia* swamp sclerophyll forest (WLC021).

Cynanchum carnosum (Apocynaceae)

Reaches southern limit of distribution in the vicinity of Wallis Lake (PlantNET).

Recorded in *Casuarina glauca* swamp sclerophyll forest (WLC031) and *Casuarina glauca – Melaleuca quinquenervia* swamp sclerophyll woodland (BBY048).

Adenostemma lavenia var. *lavenia* (Asteraceae)

Collections at the Royal Botanic Gardens, Sydney (pers. com. 2007) mostly date from more than 50 years ago (1848–1964); may now be rare across its range in coastal northern NSW.

Recorded in swamp sclerophyll forest dominated by *Melaleuca linariifolia* (WLC009), or by varying combinations of *Casuarina glauca, Eucalyptus robusta* and *Melaleuca quinquenervia* (WLC006, WLC011, WLC039).

Almaleea paludosa (Fabaceae – Faboideae)

Apparently uncommon on the NSW North Coast (Griffith et al. 2003, PlantNET).

Recorded in *Melaleuca sieberi* swamp sclerophyll shrubland (NAB010).

Pultenaea blakelyi (Fabaceae – Faboideae)

Apparently reaches the northern limit of its coastal distribution in the vicinity of Wallis Lake (PlantNET).

Recorded in swamp sclerophyll forest or woodland dominated by varying combinations of *Casuarina glauca, Eucalyptus resinifera, Eucalyptus robusta, Livistona australis* and *Melaleuca quinquenervia* (WLC024, WLC032, WLC040, BBY043).

Gonocarpus salsoloides (Haloragaceae)

Listed as Rare (3RCa) on ROTAP.

Recorded in *Banksia ericifolia* subsp. *macrantha* swamp sclerophyll shrubland (NAB022) and *Melaleuca sieberi* swamp sclerophyll shrubland (NAB010, NAB011).

Lycopus australis (Lamiaceae)

Possibly infrequent on the NSW North Coast (PlantNET).

Recorded in swamp sclerophyll forest or woodland dominated by varying combinations of *Casuarina glauca, Eucalyptus robusta* and *Melaleuca quinquenervia* (WLC012, WLC039).

Isotoma armstrongii (Lobeliaceae)

Confined to the North Coast in NSW where possibly infrequent (PlantNET).

Recorded in *Casuarina glauca* swamp sclerophyll forest (WLC037), and in a clearing near WLC020.

Villarsia reniformis (Menyanthaceae)

PlantNET has few records for the NSW North Coast.

Recorded in *Baumea articulata* sedgeland (WLC001).

Callistemon citrinus (Myrtaceae)

Apparently rare on the coastal lowlands of NSW north of Wallis Lake (Griffith and Wilson 2007, PlantNET).

Recorded in wet heathland (NAB003, NAB004, NAB005, NAB014, BBY019), *Banksia ericifolia* subsp. *macrantha* swamp sclerophyll shrubland (NAB022) and *Eucalyptus robusta* swamp sclerophyll forest or woodland (WLC019).

Leptospermum arachnoides (Myrtaceae)

Apparently rare on the coastal lowlands of NSW north of the Forster district (Griffith et al. 2003, PlantNET).

Recorded in wet heathland (NAB005), *Banksia ericifolia* subsp. *macrantha* swamp sclerophyll shrubland (NAB015) and *Melaleuca sieberi* swamp sclerophyll shrubland (NAB010, NAB011).

Melaleuca ericifolia (Myrtaceae)

Apart from a possible outlier in the vicinity of Coffs Harbour, extends south from the Coopernook area near Taree (PlantNET).

Dominates the tallest stratum in swamp sclerophyll shrubland (WLC008, WLC022), which may grade structurally into wet heathland. Also recorded in swamp sclerophyll forest or woodland dominated by *Melaleuca linariifolia* (WLC009), *Casuarina glauca* (WLC016, WLC034, WLC044), or varying combinations of *Casuarina glauca, Livistona australis* and *Melaleuca quinquenervia* (WLC013, WLC033).

Persicaria dichotoma (Polygonaceae)

Confined to coastal lowlands on the mid and upper North Coast in NSW, where considered rare (PlantNET).

Recorded in *Casuarina glauca* swamp sclerophyll forest (WLC005).

Banksia ericifolia subsp. *macrantha* (Proteaceae)

Confined to the NSW North Coast, reaching its southern limit of distribution around Wallis Lake (PlantNET).

Recorded in swamp sclerophyll shrubland, often as the tallest stratum dominant (NAB010, NAB011, NAB015, NAB022). Also found in wet heathland (NAB003, NAB004, NAB005, WLC050, BBY019) and *Eucalyptus robusta* swamp sclerophyll forest or woodland (WLC019).

Symphionema paludosum (Proteaceae)

Relatively uncommon on the NSW North Coast where distribution restricted and disjunct (Griffith and Wilson 2007, PlantNET).

Recorded in wet heathland on the Nabiac Pleistocene barriers (Griffith and Wilson 2007).

Cryptandra ericoides (Rhamnaceae)

PlantNET has no other records for the NSW North Coast; generally occurs south from Sydney.

Recorded for wet heathland (Griffith et al. 2000), in Booti Booti NP close to the northern boundary (456650 6433025).

Durringtonia paludosa (Rubiaceae)

Characteristic of deep peat in coastal barrier wetlands where uncommon; endemic to northern NSW and southern Queensland (PlantNET).

Recorded in swamp sclerophyll forest or woodland dominated by *Eucalyptus robusta* and/or *Melaleuca quinquenervia* (WLC019, BBY023, BBY043).

Asperula asthenes (Rubiaceae)

Listed as Vulnerable under the NSW *TSC Act* and ROTAP (3VC-).

Although not observed during this study, records in the Atlas of NSW Wildlife database or otherwise held by Great Lakes Council indicate that this species occurs in the Darawakh, Pipers Bay and North Tuncurry areas (M. Bell, GLC pers. com. 2008). The habitat is swamp sclerophyll forest and woodland dominated by *Eucalyptus robusta* and/or *Melaleuca quinquenervia*, sometimes with associated *Casuarina glauca* or *Livistona australis*. It also occurs in wet sclerophyll forest.

Opercularia varia (Rubiaceae)

Apparently rare on the NSW North Coast, with a coastal distribution generally south of Newcastle (PlantNET).

Recorded in *Eucalyptus robusta* swamp sclerophyll mallee woodland (BBY044).

Lindernia alsinoides (Scrophulariaceae)

Listed as Endangered under the NSW *TSC Act*.

Recorded during 1997/98 by S. Griffith on cleared land (former swamp sclerophyll forest) adjoining the northern boundary of Booti Booti NP, although not relocated during the present study. Also recorded more recently in disturbed wetlands and clearings in the vicinity of south Forster and north Tuncurry (M. Bell, GLC pers. com. 2008).

Discussion

The coastal wetlands of NSW have significant environmental and social values (Adam et al. 1985), although in some habitats wetland vegetation has been substantially cleared or severely modified (Keith and Scott 2005, Pressey and Griffith 1992). Apart from saltmarsh and mangroves (e.g. Adam et al. 1988, West et al. 1984, 1985), and wetlands of beach ridge plains, dunefields and associated landforms (e.g. Griffith et al. 2003, Griffith and Wilson 2007), the floristic composition and spatial distribution of many coastal wetlands is not well known for northern NSW (Griffith 2005), and it seems likely that a substantial proportion of wetland plant communities are poorly represented in existing conservation reserves.

The present study has identified floristic differences between wetlands in different habitats and, to a lesser extent, floristic differences between wetlands comprising different structural formations. Between-habitat differences in floristic composition for multi-stratum vegetation generally relate to understorey strata. Biodiversity conservation of wetland vegetation within the Wallis Lake catchment therefore requires the protection of representative samples across the full range of vegetation formations and habitats.

Existing conservation reserves within the Wallis Lake catchment contain wetlands associated with aeolian/barrier, estuarine and swamp soil landscapes, e.g. Booti Booti National Park and Yahoo Island Nature Reserve (Griffith et al. 2000). Nonetheless, limitations of resolution and reliability for existing catchment-wide vegetation mapping preclude its use to assess the adequacy of current reserves for the protection of wetland biodiversity. Another potential limitation of the mapping is the inability of conventional API to discriminate spatial patterns for understorey strata in multi-stratum vegetation, such as swamp sclerophyll forest, which supports the same tallest stratum species across a range of habitats. However, when used in conjunction with soil landscape mapping, API-derived vegetation mapping of acceptable resolution and reliability is likely to adequately portray environmental variation and plant biodiversity, irrespective of vegetation structure.

Wetland vegetation in the Wallis Lake catchment has known conservation significance. Coastal Saltmarsh, for example, is an Endangered Ecological Community (EEC) under the NSW *TSC Act*. This vegetation is widespread around Wallis Lake where associated with brackish to tidal flats and depressions (groups 3, 4, 7 and 8 in Figure 5). Included in Coastal Saltmarsh are rushlands dominated by *Phragmites australis* or *Juncus kraussii* subsp. *australiensis*, sedgelands dominated by *Baumea juncea*, *Bolboschoenus caldwellii* or *Schoenoplectus subulatus*, chenopod shrublands dominated by *Sarcocornia quinqueflora* subsp. *quinqueflora* or *Suaeda australis*, and *Sporobolus virginicus* tussock grassland.

Wetlands in the catchment also support components of other Endangered Ecological Communities – Swamp Oak Floodplain Forest, Swamp Sclerophyll Forest on Coastal Floodplains, and Freshwater Wetlands on Coastal Floodplains. As delineated by Keith and Scott (2005), these vegetation types are not well known in relation to species dominance, particularly in the understorey for forests, and their habitats are only loosely circumscribed in reference to soil landscapes. As a consequence, the differences in floristic composition and habitat are not clear between say, Swamp Sclerophyll Forest on Coastal Floodplains, and the least saline examples of Swamp Oak Floodplain Forest. Differences in fire response may also confound distinctions between swamp sclerophyll forests, e.g. where a severe fire kills the crowns of mature *Casuarina glauca* in mixed stands with *Melaleuca quinquenervia*, whereas the latter species resprouts from epicormic buds. Despite these issues, the following floristic groups identified for the Wallis Lake catchment most likely align with the EEC's.

Swamp Oak Floodplain Forest

This EEC comprises swamp sclerophyll forest or woodland dominated by *Casuarina glauca*, particularly representing groups 5 and 6 (Figure 3) on brackish to upper tidal flats or in associated prior stream channels. Also included in the EEC would be stands in group 3b on extratidal plains (former estuaries) where *Casuarina glauca* clearly dominates. Understorey composition varies with habitat and water quality (brackish to saline), although common species include *Baumea juncea*, *Juncus kraussii* subsp. *australiensis*, *Phragmites australis* and *Sporobolus virginicus*. More restricted understorey species, as in prior stream channels, include *Alocasia brisbanensis*, *Hypolepis muelleri*, *Melaleuca ericifolia*, *Melaleuca styphelioides* and *Myoporum acuminatum*.

Swamp Sclerophyll Forest on Coastal Floodplains

Typical of this EEC are the swamp sclerophyll forests of groups 3a and 3c (Figure 3), on extratidal plains and associated alluvial and transferral landforms where freshwater conditions prevail. *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* dominate the tallest stratum in varying combinations, with *Eucalyptus grandis*, *Eucalyptus resinifera*, *Eucalyptus tereticornis* or *Livistona australis* sometimes subsidiary to co-dominant. Also included are localised stands of *Melaleuca linariifolia*. The understorey is typically diverse, although common species include *Entolasia marginata*, *Gahnia clarkei*, *Hypolepis muelleri*, *Imperata cylindrica* var. *major*, *Ischaemum australe* and *Melaleuca linariifolia*. Some stands also support various rainforest shrubs or small trees beneath the tallest stratum (e.g. *Glochidion ferdinandi*).

Freshwater Wetlands on Coastal Floodplains

This EEC is represented in the catchment by the herbaceous vegetation of shallow to deep freshwater swamps (closed depressions). Included are sedgelands dominated by *Baumea articulata*, *Eleocharis equisetina* or *Eleocharis sphacelata*, and also *Paspalum distichum* sod grassland (groups 1 and 2 in Figure 5).

The present study demonstrates a high degree of congruence between floristic composition and habitat (i.e. soil landscape), thereby providing a mechanism to facilitate the delineation of EEC's throughout the Wallis Lake catchment. This is particularly the case for floodplain forests and woodlands, which are most reliably distinguished by floristic composition of the understorey rather than the tallest stratum.

Recommendations

A key recommendation arising from this study is the completion of reliable mapping for wetland vegetation and soil landscapes across all land tenures throughout the Wallis Lake catchment, including an assessment of disturbance impacts. Mapping of acceptable resolution and reliability will facilitate planning, conservation and management, specifically for:

(a) the evaluation of wetland condition (e.g. Bolton 2001a, b) and significance, e.g. types and extent of disturbance, landuse constraints, threats to function and integrity, and intrinsic conservation values; and

(b) an assessment of the extent and representation of wetland vegetation in formal conservation reserves (e.g. national parks), thereby directing future priorities for the protection of wetland biodiversity on both public and private lands.

The environmental services provided by wetlands are widely recognised (e.g. NSW Government 1996). The Great Lakes community relies upon a high quality natural environment for key economic drivers (e.g. tourism, oyster production, commercial fishing), and the environmental service provisions of functioning wetlands are therefore important. Spatial information about wetland type, habitat, extent, tenure, condition and intrinsic conservation values will facilitate the development of a strategy and action plan to enact proper and reasonable wetland conservation, management and restoration throughout the Wallis Lake catchment.

Kingsford et al. (2003) noted that "*it is difficult to manage any natural resource without knowing its distribution and* *wetlands are no exception. Without a spatial context, effective conservation measures are difficult to implement because they should be contingent on the identification of threats and their operating scale... It follows that without this information, priorities for wetland protection or rehabilitation cannot be derived nor regional rates of wetland loss determined nor conservation priorities (set) for particular types of wetlands.*" It is considered appropriate to develop a wetland strategy for the Wallis Lake catchment within this context.

Wetland classification and delineation is challenged by considerable hydrological, ecological and geomorphological variability (Kingsford et al. 2003). Nonetheless, this study, using conventional API, site-based sampling and landscape differentiation provides a framework for the conservation of wetland biodiversity within the Wallis Lake catchment. Such an approach is likely to facilitate wetland conservation in the Smiths Lake, Myall Lake and Karuah River catchments within the Great Lakes LGA, and more widely throughout coastal NSW.

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Appendix 1. Frequency and mean foliage cover of vascular species in wetland floristic groups.

Floristic groups are numbered and described as they appear in Figures 3–5. Frequency of occurrence (first value in brackets) is the percentage of quadrats in which a species occurred. Mean foliage cover (second value in brackets) is the average of scores for quadrats in which a species occurred. Foliage cover scores: 1 (<1%); 2 (1–5%); 3 (6–25%); 4 (26–50%); 5 (51–75%); and 6 (76–100%). Exotic taxa are prefixed with an asterisk. Abbreviations: SSF/W: swamp sclerophyll forest/woodland; MF/W: mangrove forest/woodland; SSS: swamp sclerophyll shrubland; SSMW: swamp sclerophyll mallee woodland; S: sedgeland; SG: sod grassland; R: rushland; CS: chenopod shrubland; WH: wet heathland; TG: tussock grassland.

SSF–1: *Melaleuca quinquenervia* SSF in a deep freshwater swamp (1 quadrat)

SSF/W–2: *Eucalyptus robusta* SSF/W and *E. robusta – Melaleuca quinquenervia* SSF/W associated with sand barrier open depressions and flats (6 quadrats)

SSF/W–3a: SSF (occasionally SSW) on extratidal plains (former estuaries) and associated alluvial landforms, dominated by *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations, with *Eucalyptus grandis*, *E. resinifera*, *E. tereticornis* or *Livistona australis* sometimes subsidiary to co-dominant; also localised *Melaleuca linariifolia* SSF (15 quadrats)

SSF/W–3b: SSF/W on extratidal plains with inferred residual soil salinity, dominated by *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations (6 quadrats)

SSF–3c: *Casuarina glauca – Eucalyptus robusta – Livistona australis* SSF along a transferral drainage depression (1 quadrat)

SSF–4: *Melaleuca nodosa* SSF on a transferral drainage plain (1 quadrat)

SSF/W–5: *Casuarina glauca* SSF and *C. glauca – Melaleuca quinquenervia* SSF/W on brackish to upper tidal flats of contemporary estuary (11 quadrats)

SSF/W–6: *Casuarina glauca* SSF/W along prior stream channels associated with supratidal flats (2 quadrats)

MF/W–7: *Avicennia marina* subsp. *australasica* MF/W on intertidal flats (2 quadrats)

SSS–1a: *Melaleuca sieberi* SSS on sand barrier flats (2 quadrats)

SSS–1b: *Banksia ericifolia* subsp. *macrantha* SSS in sand barrier swales (2 quadrats)

SSS–2a: *Melaleuca ericifolia* SSS on extratidal plains with inferred residual soil salinity (2 quadrats)

SSMW–2b: *Eucalyptus robusta* SSMW along a sand barrier drainage depression (1 quadrat)

SSS–3: *Melaleuca quinquenervia* SSS in a brackish swamp (1 quadrat)

S–1: *Baumea articulata* S and *Eleocharis sphacelata* S in deep freshwater swamps (3 quadrats)

S/SG–2: *Eleocharis equisetina* S and *Paspalum distichum* SG in shallow freshwater swamps (2 quadrats)

R/S–3: *Phragmites australis* R, *Bolboschoenus caldwellii* S and *Schoenoplectus subulatus* S associated with brackish depressions and flats near estuary (5 quadrats)

R/S/CS–4: *Phragmites australis* R, *Baumea juncea* S and *Suaeda australis* CS on supratidal flats (6 quadrats)

WH–5: WH of *Banksia oblongifolia*, *Hakea teretifolia* subsp. *teretifolia*, *Leptospermum liversidgei*, *Xanthorrhoea fulva* etc., associated with sand barrier swales and flats (6 quadrats)

S–6: *Baloskion pallens – Leptocarpus tenax – Schoenus brevifolius* etc. S and *Lepironia articulata* S in sand barrier acid swamps (4 quadrats)

R/TG–7: *Juncus kraussii* subsp. *australiensis* R and *Sporobolus virginicus* TG on upper tidal flats (22 quadrats)

CS/TG–8: *Sarcocornia quinqueflora* subsp. *quinqueflora* CS and *S. quinqueflora* subsp. *quinqueflora – Sporobolus virginicus* CS/TG on lower tidal flats (11 quadrats)

Class LYCOPSIDA					
LYCOPODIACEAE					
Lycopodiella lateralis	SSS-1b (50%,2.00)	WH-5 (17%,3.00)			
SELAGINELLACEAE					
Selaginella uliginosa	SSF/W-2 (33%,1.50) SSS-2a (50%,2.00)	SSF/W-3a (20%,1.33) WH-5 (50%,1.67)	SSF/W-3b (17%,1.00)	SSS-1a (100%,1.50)	SSS-1b (50%,1.00)
Class FILICOPSIDA					
ASPLENIACEAE					
Asplenium australasicum	SSF/W-6 (50%,1.00)				
ADIANTACEAE					
Adiantum aethiopicum	SSF/W-3a (7%,1.00)				
AZOLLACEAE					
Azolla pinnata	S/SG-2 (50%,1.00)				
BLECHNACEAE					
Blechnum camfieldii	SSF/W-2 (17%,1.00)	SSF/W-3b (17%,1.00)			
Blechnum indicum	SSF-1 (100%,1.00) SSS-2a (50%,1.00)	SSF/W-2 (100%,2.83) SSMW-2b (100%,1.00)	SSF/W-3a (53%,1.75) R/S-3 (40%,1.50)	SSF/W-3b (50%,2.67) S-6 (25%,1.00)	SSF/W-5 (9%,2.00)
CULCITACEAE					
Calochlaena dubia	SSF/W-3a (13%,1.00)	SSF-3c (100%,2.00)			
CYATHEACEAE					
Cyathea cooperi	SSF-3c (100%,1.00)				
DENNSTAEDTIACEAE					
Histiopteris incisa	SSF/W-3a (7%,3.00)	SSF/W-5 (9%,1.00)			
Hypolepis muelleri	SSF/W-2 (17%,1.00)	SSF/W-3a (53%,2.50)	SSF-3c (100%,2.00)	SSF/W-5 (9%,2.00)	SSF/W-6 (50%,5.00
Pteridium esculentum	SSF/W-2 (83%,2.40)	SSF/W-3a (73%,2.09)	SSF/W-3b (33%,1.50)	SSMW-2b (100%,2.00)	
GLEICHENIACEAE					
Gleichenia microphylla	SSF/W-2 (33%,4.50)	WH-5 (17%,1.00)			
LINDSAEACEAE					
Lindsaea linearis	WH-5 (17%,2.00)				
OPHIOGLOSSACEAE					
Botrychium australe	SSF/W-3a (20%,1.00)				
POLYPODIACEAE					
Platycerium bifurcatum	SSF/W-3a (27%,1.25)	SSF/W-3b (17%,1.00)	SSF/W-6 (100%,1.00)		
Pyrrosia confluens var. *dielsii*	SSF/W-3a (13%,1.00)	SSF/W-6 (50%,1.00)			
Pyrrosia rupestris	SSF/W-6 (50%,1.00)				
SCHIZAEACEAE					
Schizaea bifida	WH-5 (17%,1.00)				
SINOPTERIDACEAE					
Cheilanthes sieberi subsp. *sieberi*	SSF-4 (100%,1.00)				
Pellaea falcata	SSF/W-6 (50%,1.00)				
THELYPTERIDACEAE					
Christella dentata	SSF/W-3a (7%,1.00)				
Cyclosorus interruptus	SSF/W-3a (20%,2.00)	SSF/W-5 (9%,1.00)			

Class MAGNOLIOPSIDA – LILIIDAE

AMARYLLIDACEAE					
Crinum pedunculatum	SSF-3c (100%,2.00)	SSF/W-5 (9%,1.00)			
ANTHERICACEAE					
Arthropodium species B	SSF-4 (100%,1.00)				
Caesia parviflora var. *parviflora*	SSF/W-3a (7%,1.00)				
Sowerbaea juncea	WH-5 (17%,1.00)				
ARACEAE					
Alocasia brisbanensis	SSF/W-3a (7%,1.00)	SSF/W-6 (50%,3.00)			
ARECACEAE					
Livistona australis	SSF/W-2 (33%,1.50)	SSF/W-3a (80%,1.83)	SSF/W-3b (33%,1.00)	SSF-3c (100%,4.00)	SSF/W-5 (9%,1.00)
	SSF/W-6 (50%,1.00)				
BLANDFORDIACEAE					
Blandfordia grandiflora	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)	WH-5 (50%,1.00)		
COLCHICACEAE					
Burchardia umbellata	WH-5 (17%,1.00)				
COMMELINACEAE					
Commelina cyanea	SSF/W-3a (20%,1.00)	SSF/W-3b (17%,1.00)	SSF/W-5 (27%,1.00)	SSF/W-6 (50%,2.00)	
CYPERACEAE					
Baumea arthrophylla	S-6 (75%,2.00)				
Baumea articulata	SSF-1 (100%,4.00)	SSF/W-3a (47%,1.43)	SSF/W-3b (100%,1.83)	SSF/W-5 (18%,1.50)	SSS-2a (100%,1.00)
	SSS-3 (100%,2.00)	S-1 (67%,4.50)	R/S-3 (20%,1.00)	R/S/CS-4 (17%,1.00)	
Baumea juncea	SSF/W-2 (17%,3.00)	SSF/W-3a (40%,2.50)	SSF/W-3b (67%,3.75)	SSF/W-5 (73%,3.25)	SSF/W-6 (50%,1.00)
	SSS-2a (100%,3.00)	SSMW-2b (100%,2.00)	SSS-3 (100%,2.00)	R/S/CS-4 (100%,4.50)	R/TG-7 (9%,2.00)
Baumea muelleri	WH-5 (17%,1.00)				
Baumea rubiginosa	SSF-1 (100%,2.00)	SSF/W-2 (33%,2.50)	SSF/W-3a (40%,2.33)	SSF/W-3b (50%,2.67)	SSS-2a (50%,1.00)
	SSS-3 (100%,1.00)	R/S/CS-4 (17%,1.00)			
Baumea teretifolia	SSF-1 (100%,2.00)	SSF/W-2 (50%,2.00)	SSF/W-3a (20%,1.00)	SSF/W-3b (33%,2.00)	SSS-2a (50%,1.00
	WH-5 (33%,1.50)	S-6 (75%,2.67)			
Bolboschoenus caldwellii	R/S-3 (40%,4.00)				
Carex appressa	SSF/W-3a (13%,1.50)	SSF/W-6 (50%,1.00)			
Carex declinata	SSF/W-3a (7%,1.00)				
Carex lobolepis	SSF/W-3a (7%,1.00)				
Carex maculata	SSF/W-3a (27%,2.25)	SSF/W-3b (33%,2.50)	SSF/W-5 (18%,1.00)		
Chorizandra cymbaria	SSF/W-2 (17%,1.00)	SSF/W-3a (7%,2.00)	SSF/W-3b (33%,1.50)		
Chorizandra sphaerocephala	SSF/W-2 (33%,2.00)	SSS-1b (50%,1.00)	WH-5 (67%,1.75)		
Cyperus haspan subsp. *haspan*	SSF/W-3a (7%,1.00)				
Cyperus lucidus	SSF/W-3b (17%,1.00)				
Cyperus polystachyos	SSF/W-3a (20%,1.00)	SSF/W-5 (27%,1.00)	R/S/CS-4 (17%,3.00)		
**Cyperus rotundus*	R/S/CS-4 (17%,2.00)				
Eleocharis equisetina	SSF/W-5 (9%,3.00)	S/SG-2 (100%,3.00)	R/S-3 (20%,2.00)		
Eleocharis sphacelata	S-1 (100%,2.33)				
Ficinia nodosa	SSF/W-5 (9%,1.00)				
Fimbristylis dichotoma	SSF/W-3a (13%,1.00)	SSF/W-5 (9%,1.00)			
Fimbristylis ferruginea	SSF/W-5 (36%,1.25)	SSF/W-6 (50%,1.00)	SSS-3 (100%,2.00)	R/S/CS-4 (33%,2.00)	R/TG-7 (18%,1.75)
Gahnia clarkei	SSF/W-2 (100%,1.83)	SSF/W-3a (100%,2.80)	SSF/W-3b (100%,2.50)	SSF-3c (100%,5.00)	SSF/W-5 (45%,1.60)
	SSS-2a (100%,2.00)	SSMW-2b (100%,2.00)	R/S-3 (20%,1.00)		
Gahnia sieberiana	SSS-1b (50%,1.00)	WH-5 (50%,2.33)			
Isolepis cernua	R/TG-7 (5%,2.00)				

Isolepis inundata	SSF/W-2 (33%,1.00)	SSF/W-3a (27%,1.50)	SSF/W-3b (33%,1.50)	R/S/CS-4 (17%,3.00)	
Lepidosperma filiforme	SSS-1b (50%,3.00)				
Lepidosperma gunnii	SSS-1a (50%,1.00)				
Lepidosperma limicola	SSS-1a (50%,3.00)	WH-5 (33%,2.00)			
Lepidosperma longitudinale	SSF-1 (100%,2.00)				
Lepidosperma neesii	SSF-4 (100%,3.00)	WH-5 (17%,2.00)			
Lepidosperma quadrangulatum	SSF/W-2 (17%,3.00)	SSF-4 (100%,3.00)			
Lepironia articulata	S-6 (50%,3.00)				
Ptilothrix deusta	SSS-1a (100%,4.00)	SSS-1b (50%,2.00)	WH-5 (50%,2.67)		
Rhynchospora brownii	SSF/W-3a (7%,1.00)	SSF/W-3b (17%,1.00)			
Schoenoplectus subulatus	SSS-3 (100%,2.00)	R/S-3 (20%,5.00)	R/S/CS-4 (17%,2.00)		
Schoenus apogon	SSF/W-3a (20%,1.33)	SSF/W-3b (17%,1.00)			
Schoenus brevifolius	SSF/W-2 (33%,2.50) SSMW-2b (100%,2.00)	SSF/W-3a (7%,2.00) WH-5 (67%,1.75)	SSF/W-3b (17%,1.00) S-6 (25%,3.00)	SSS-1a (100%,2.00)	SSS-1b (100%,2.00)
Schoenus melanostachys	SSF-3c (100%,1.00)				
Schoenus paludosus	SSS-1a (100%,1.00)	WH-5 (17%,1.00)			
Schoenus scabripes	WH-5 (17%,2.00)				
Schoenus sp.	R/TG-7 (5%,1.00)				
GEITONOPLESIACEAE					
Eustrephus latifolius	SSF/W-3a (7%,1.00)				
Geitonoplesium cymosum	SSF/W-3a (13%,1.00)	SSF-3c (100%,1.00)			
HAEMODORACEAE					
Haemodorum corymbosum	SSS-1a (100%,1.00)	WH-5 (17%,1.00)			
HYPOXIDACEAE					
Hypoxis pratensis var. *pratensis*	SSF/W-3a (7%,1.00)	SSF-4 (100%,1.00)			
IRIDACEAE					
Patersonia sericea	WH-5 (17%,1.00)				
Patersonia sp. aff. *fragilis*	SSS-1a (50%,1.00)	WH-5 (17%,1.00)			
JUNCACEAE					
**Juncus cognatus*					
Juncus continuus	SSF/W-3a (7%,1.00)				
Juncus kraussii subsp. *australiensis*	SSF/W-3b (33%,1.00) R/S-3 (20%,3.00)	SSF/W-5 (82%,2.56) R/S/CS-4 (33%,3.00)	SSF/W-6 (50%,2.00) R/TG-7 (95%,3.86)	MF/W-7 (100%,1.50) CS/TG-8 (27%,1.67)	SSS-3 (100%,4.00)
Juncus mollis	SSF/W-3a (13%,1.00)				
Juncus polyanthemus	SSF/W-3a (7%,1.00)	SSF/W-3b (33%,1.00)			
Juncus prismatocarpus					
Juncus usitatus	SSF/W-3a (7%;1.00)				
JUNCAGINACEAE					
Maundia triglochinoides	SSF-1 (100%,3.00)				
Triglochin procerum s. lat.	SSF-1 (100%,1.00) R/S-3 (20%,1.00)	SSF/W-2 (17%,1.00) S-6 (50%,1.00)	SSF/W-5 (18%,1.00)	S-1 (67%,1.50)	S/SG-2 (50%,1.00)
Triglochin striatum	SSF/W-5 (27%,1.33)	R/S-3 (20%,3.00)	R/TG-7 (18%,2.25)	CS/TG-8 (73%,2.63)	
LAXMANNIACEAE					
Cordyline stricta	SSF/W-3a (7%,1.00)				
LEMNACEAE					
Spirodela punctata					

LOMANDRACEAE					
Lomandra longifolia	SSF/W-2 (17%,2.00)	SSF/W-3a (47%,1.71)	SSF/W-3b (33%,1.00)	SSF-3c (100%,1.00)	SSMW-2b (100%,1.00)
	WH-5 (17%,1.00)				
Lomandra multiflora subsp. *multiflora*	SSF-4 (100%,1.00)				
ORCHIDACEAE					
Acianthus sp.	SSF-4 (100%,1.00)	SSMW-2b (100%,1.00)			
Caladenia picta	SSF-4 (100%,1.00)				
Cryptostylis sp.	SSF/W-3b (50%,1.00)				
Cryptostylis subulata	SSF/W-3a (7%,1.00)				
Cymbidium suave	SSF/W-3a (7%,1.00)				
Dockrillia teretifolia	SSF/W-3a (20%,1.00)	SSF/W-5 (9%,1.00)			
Plectorrhiza tridentata	SSF/W-3b (17%,1.00)				
Pterostylis sp.	SSF/W-3a (27%,1.00)				
PHILYDRACEAE					
Philydrum lanuginosum	SSF/W-3a (13%,1.00)	SSF/W-3b (50%,1.00)	S/SG-2 (50%,1.00)		
PHORMIACEAE					
Dianella caerulea	SSF/W-2 (50%,1.00)	SSF/W-3a (100%,1.20)	SSF/W-3b (50%,1.00)	SSF-4 (100%,1.00)	SSMW-2b (100%,3.00)
Dianella longifolia	SSF/W-3a (7%,1.00)	SSF/W-5 (9%,1.00)	SSF/W-6 (50%,1.00)		
Dianella revoluta	SSF-4 (100%,1.00)				
POACEAE					
Agrostis sp.	R/S/CS-4 (17%,1.00)	R/TG-7 (5%,1.00)			
**Andropogon virginicus*	SSF/W-3a (40%,1.00)	SSF-4 (100%,1.00)	SSMW-2b (100%,1.00)	S-6 (25%,1.00)	
Aristida vagans	SSF-4 (100%,2.00)				
**Axonopus fissifolius*	SSF/W-3a (53%,1.38)				
**Cortaderia selloana*	SSF/W-5 (9%,1.00)				
Cynodon dactylon	SSF/W-3a (7%,1.00)	SSF/W-3b (17%,1.00)	SSF/W-6 (50%,1.00)		
Deyeuxia quadriseta	SSF/W-3b (17%,1.00)				
Dichelachne micrantha	SSF/W-3a (7%,1.00)				
Echinopogon ovatus	SSF/W-3a (20%,1.00)				
**Ehrharta erecta*	SSF/W-5 (9%,1.00)				
Entolasia marginata	SSF/W-3a (100%,2.20)	SSF/W-3b (50%,1.33)	SSF-3c (100%,1.00)	SSF/W-5 (9%,1.00)	SSF/W-6 (50%,2.00)
	SSS-2a (50%,2.00)				
Entolasia stricta	SSF/W-2 (83%,1.40)	SSF/W-3a (13%,2.00)	SSF/W-3b (17%,1.00)	SSF-3c (100%,1.00)	SSF-4 (100%,3.00)
	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)	SSS-2a (50%,1.00)	WH-5 (67%,1.25)	
Eragrostis benthamii	SSF/W-3a (7%,1.00)				
Eragrostis brownii	SSF/W-3a (13%,2.00)	SSF/W-3b (17%,1.00)	SSF-4 (100%,1.00)		
Eriochloa procera	SSF/W-5 (9%,4.00)	R/S/CS-4 (17%,1.00)			
Hemarthria uncinata	SSF/W-2 (67%,1.50)	SSF/W-3a (87%,1.62)	SSF/W-3b (83%,2.00)	SSF/W-5 (9%,2.00)	SSS-2a (100%,3.00)
Imperata cylindrica var. *major*	SSF/W-2 (33%,1.00)	SSF/W-3a (93%,2.29)	SSF/W-3b (83%,2.40)	SSF-3c (100%,1.00)	SSF-4 (100%,3.00)
	SSS-2a (100%,2.00)	SSMW-2b (100%,3.00)			
Isachne globosa	SSF/W-2 (17%,2.00)	SSF/W-3a (27%,1.25)	SSF/W-3b (33%,1.50)	SSF/W-6 (50%,1.00)	S-1 (33%,1.00)
	S/SG-2 (50%,1.00)				
Ischaemum australe	SSF/W-2 (50%,2.00)	SSF/W-3a (47%,2.71)	SSF/W-3b (83%,2.00)	SSS-2a (50%,3.00)	WH-5 (17%,1.00)
Leersia hexandra	SSF-1 (100%,2.00)	SSF/W-2 (17%,1.00)			
Microlaena stipoides var. *stipoides*	SSF/W-3a (67%,1.20)	SSF/W-6 (50%,3.00)			
Oplismenus aemulus	SSF/W-3a (67%,1.40)	SSF/W-6 (50%,3.00)			
Oplismenus imbecillis	SSF/W-3a (47%,1.86)	SSF-3c (100%,1.00)			
Ottochloa gracillima	SSF/W-3a (7%,5.00)				
Panicum bisulcatum	SSF/W-3a (7%,1.00)				

Panicum simile	SSF/W-2 (17%,1.00)	SSF/W-3a (13%,1.00)	SSF-4 (100%,2.00)	SSS-1a (50%,1.00)	SSS-1b (50%,1.00)
	WH-5 (17%,1.00)				
Paspalidium distans	SSF/W-2 (17%,1.00)	SSF/W-3a (53%,1.25)	SSF/W-3b (33%,1.00)	SSF-4 (100%,1.00)	SSF/W-6 (50%,2.00)
	SSMW-2b (100%,1.00)				
**Paspalum dilatatum*	SSF/W-3a (13%,1.50)				
Paspalum distichum	S/SG-2 (50%,5.00)				
Paspalum orbiculare	SSF/W-3a (53%,1.13)	SSF/W-3b (50%,1.00)			
**Paspalum urvillei*	SSF/W-3a (20%,1.00)				
**Paspalum wettsteinii*	SSF/W-3a (7%,1.00)				
Phragmites australis	SSF/W-2 (33%,1.00)	SSF/W-3a (20%,1.00)	SSF/W-3b (67%,1.50)	SSF/W-5 (64%,2.43)	SSF/W-6 (50%,2.00)
	R/S-3 (80%,4.50)	R/S/CS-4 (50%,2.67)	R/TG-7 (9%,3.00)		
Poa labillardieri	SSF/W-3a (13%,2.00)				
**Polypogon monspeliensis*	R/TG-7 (5%,2.00)				
Pseudoraphis paradoxa	SSF-1 (100%,1.00)				
Sacciolepis indica	SSF/W-3a (20%,1.00)	SSF/W-3b (17%,1.00)			
**Setaria gracilis*	SSF/W-5 (9%,1.00)				
Sporobolus diander	SSF/W-3a (7%,1.00)				
Sporobolus laxus	SSF/W-3a (7%,1.00)	SSF-4 (100%,1.00)			
Sporobolus virginicus	SSF/W-5 (73%,2.38)	SSF/W-6 (50%,3.00)	MF/W-7 (100%,3.00)	R/S/CS-4 (50%,2.67)	R/TG-7 (95%,5.38)
	CS/TG-8 (64%,3.43)				
Themeda australis	SSF/W-3a (27%,2.75)				
Zoysia macrantha	SSF/W-5 (9%,2.00)				
POTAMOGETONACEAE					
**Ruppia maritima*	R/S/CS-4 (17%,2.00)	CS/TG-8 (9%,1.00)			
RESTIONACEAE					
Baloskion pallens	SSS-1b (100%,1.00)	SSMW-2b (100%,1.00)	WH-5 (33%,2.00)	S-6 (75%,3.67)	
Baloskion tetraphyllum subsp. *meiostachyum*	SSF/W-2 (100%,3.50)	SSF/W-3b (17%,3.00)	SSMW-2b (100%,4.00)		
Empodisma minus	SSF/W-2 (33%,3.00)	SSF/W-3a (7%,4.00)	WH-5 (50%,4.00)		
Eurychorda complanata	SSS-1a (50%,1.00)	SSS-1b (100%,2.00)	WH-5 (33%,1.50)		
Hypolaena fastigiata	WH-5 (17%,2.00)				
Leptocarpus tenax	SSF/W-2 (33%,2.50)	SSS-1a (100%,3.00)	SSS-1b (100%,1.50)	SSS-2a (50%,3.00)	SSMW-2b (100%,1.00)
	WH-5 (67%,2.25)	S-6 (25%,2.00)			
Lepyrodia scariosa	SSS-1a (50%,2.00)	SSS-1b (50%,1.00)	WH-5 (33%,1.50)		
Lepyrodia sp. A ('*imitans*')	SSF/W-2 (33%,1.50)	SSS-1a (50%,2.00)	WH-5 (17%,1.00)		
Sporadanthus caudatus	SSS-1b (50%,1.00)				
Sporadanthus interruptus	SSS-1b (100%,1.50)	SSMW-2b (100%,1.00)	WH-5 (67%,2.25)		
SMILACACEAE					
Smilax glyciphylla	SSF/W-3a (7%,1.00)				
TYPHACEAE					
Typha domingensis	SSF/W-3a (7%,1.00)				
XANTHORRHOEACEAE					
Xanthorrhoea fulva	SSF/W-2 (67%,1.25)	SSS-1a (50%,1.00)	SSS-1b (100%,2.50)	WH-5 (67%,2.75)	
XYRIDACEAE					
Xyris gracilis subsp. *gracilis*	SSS-1a (50%,1.00)	WH-5 (17%,1.00)			
Xyris juncea	SSS-1a (50%,1.00)				
Xyris operculata	SSS-1a (100%,2.00)	SSS-1b (100%,2.00)	WH-5 (67%,2.00)		

Class MAGNOLIOPSIDA – MAGNOLIIDAE

ACANTHACEAE					
Pseuderanthemum variabile	SSF/W-3a (20%,1.00)				
AIZOACEAE					
Sesuvium portulacastrum	R/S/CS-4 (17%,3.00)				
Tetragonia tetragonioides	SSF/W-5 (9%,1.00)				
AMARANTHACEAE					
Alternanthera denticulata	SSF/W-5 (18%,1.00)				
APIACEAE					
Apium prostratum subsp. *prostratum*	SSF/W-5 (18%,1.00)	R/S/CS-4 (17%,2.00)	R/TG-7 (18%,2.75)	CS/TG-8 (27%,1.33)	
Centella asiatica	SSF/W-2 (17%,1.00)	SSF/W-3a (87%,1.15)	SSF/W-5 (9%,1.00)		
Hydrocotyle acutiloba	SSF/W-3a (33%,1.40)				
**Hydrocotyle bonariensis*					
Hydrocotyle peduncularis	SSF/W-2 (17%,1.00)	SSF/W-3a (87%,1.00)	SSF/W-3b (17%,1.00)	SSF-4 (100%,1.00)	
Hydrocotyle pterocarpa	SSF/W-2 (17%,1.00)				
Lilaeopsis polyantha	SSF/W-3b (17%,1.00)				
Platysace ericoides	SSS-1a (50%,1.00)	WH-5 (17%,1.00)			
Platysace lanceolata	SSMW-2b (100%,1.00)	WH-5 (17%,1.00)			
Xanthosia pilosa	WH-5 (17%,1.00)				
APOCYNACEAE					
**Araujia sericifera*	SSF/W-3a (7%,1.00)				
Cynanchum carnosum	SSF/W-5 (18%,1.50)				
**Gomphocarpus fruticosus*	SSF/W-3a (40%,1.00)	SSF/W-5 (9%,1.00)			
Marsdenia rostrata	SSF/W-3a (20%,1.33)	SSF-3c (100%,1.00)			
Marsdenia suaveolens	SSF/W-3a (7%,1.00)				
Parsonsia straminea	SSF/W-3a (80%,1.58)	SSF/W-3b (83%,1.20)	SSF/W-5 (18%,1.50)	SSS-2a (50%,1.00)	
ARALIACEAE					
Polyscias sambucifolia	SSF/W-3a (27%,1.00)				
ASTERACEAE					
Adenostemma lavenia var. *lavenia*	SSF/W-3a (27%,1.00)				
**Ageratina adenophora*	SSF/W-3a (47%,1.00)	SSF/W-6 (50%,1.00)			
**Aster subulatus*	SSF/W-3a (20%,1.00)	SSF/W-3b (17%,1.00)	SSF/W-5 (27%,1.33)	R/S-3 (20%,1.00)	R/S/CS-4 (50%,1.00)
	R/TG-7 (14%,2.00)	CS/TG-8 (9%,3.00)			
**Baccharis halimifolia*	R/S/CS-4 (17%,1.00)				
Centipeda minima	SSF/W-3a (7%,1.00)				
**Chrysanthemoides monilifera* subsp. *rotundata*	SSF/W-5 (18%,1.50)				
**Cirsium vulgare*	SSF/W-3a (27%,1.00)				
**Conyza albida*	SSF/W-3a (33%,1.00)	SSF/W-5 (9%,2.00)			
Eclipta platyglossa	SSF/W-3a (53%,1.13)	SSF/W-3b (50%,1.00)	SSF/W-5 (18%,1.00)		
Enydra fluctuans	SSF/W-3a (13%,2.00)	SSF/W-3b (17%,1.00)	SSF/W-5 (18%,1.00)	R/S/CS-4 (17%,3.00)	
Epaltes australis	SSF/W-3a (13%,1.00)				
**Erechtites valerianifolia*	SSF/W-3a (7%,1.00)				
Euchiton gymnocephalus	SSF/W-3a (13%,1.00)	SSF-4 (100%,1.00)			
**Hypochaeris radicata*	SSF/W-3a (27%,1.00)	SSF/W-5 (9%,1.00)			
Lagenifera gracilis	SSF/W-3a (27%,1.00)	SSF-4 (100%,1.00)	SSS-2a (50%,1.00)		
**Leontodon taraxacoides* subsp. *taraxacoides*	SSF/W-3a (20%,1.00)	SSF/W-3b (17%,1.00)			

Leptinella longipes	SSF/W-3a (7%,1.00)	SSF/W-3b (33%,2.00)	SSF/W-5 (18%,1.00)		
Pseudognaphalium luteoalbum	SSF/W-3a (7%,1.00)	SSF/W-5 (9%,1.00)			
Senecio hispidulus	SSF/W-3a (20%,1.00)	SSF/W-5 (9%,1.00)	SSF/W-6 (50%,1.00)		
**Senecio madagascariensis*	SSF/W-3a (27%,1.00)	SSF-4 (100%,1.00)	SSF/W-5 (36%,1.00)	SSF/W-6 (50%,1.00)	R/TG-7 (5%,2.00)
Senecio minimus	SSF/W-3a (7%,1.00)				
**Sonchus asper* subsp. *glaucescens*	SSF/W-5 (9%,1.00)				
**Sonchus oleraceus*	SSF/W-3a (7%,1.00)				
Sonchus sp.	R/TG-7 (9%,2.00)				
Vernonia cinerea var. *cinerea*	SSF/W-3a (67%,1.10)	SSF-4 (100%,1.00)	R/S/CS-4 (17%,1.00)		
**Xanthium occidentale*	SSF/W-3a (7%,1.00)	SSF/W-5 (9%,1.00)			
AVICENNIACEAE					
Avicennia marina subsp. *australasica*	MF/W-7 (100%,5.00)				
BAUERACEAE					
Bauera capitata	SSS-1a (50%,1.00)	WH-5 (17%,1.00)			
BIGNONIACEAE					
Pandorea pandorana	SSF/W-3a (13%,1.00)				
CAMPANULACEAE					
Wahlenbergia gracilis	SSF-4 (100%,1.00)				
CASUARINACEAE					
Allocasuarina littoralis	SSF/W-3a (13%,2.00)				
Casuarina glauca	SSF/W-3a (93%,2.93)	SSF/W-3b (83%,3.20)	SSF-3c (100%,3.00)	SSF/W-5 (100%,4.45)	SSF/W-6 (100%,4.50)
	MF/W-7 (50%,2.00)	SSS-2a (100%,1.50)	SSS-3 (100%,1.00)	S/SG-2 (50%,1.00)	R/S-3 (60%,1.67)
	R/S/CS-4 (17%,2.00)	R/TG-7 (18%,1.50)			
CHENOPODIACEAE					
**Atriplex prostrata*	R/S/CS-4 (17%,3.00)				
Einadia hastata	SSF/W-5 (18%,1.00)				
Sarcocornia quinqueflora subsp. *quinqueflora*	SSF/W-5 (9%,1.00)	MF/W-7 (50%,1.00)	R/S/CS-4 (17%,1.00)	R/TG-7 (73%,2.75)	CS/TG-8(100%, 5.55)
Suaeda australis	SSF/W-5 (9%,2.00)	R/S-3 (20%,1.00)	R/S/CS-4 (33%,3.00)		
CLUSIACEAE					
Hypericum gramineum	SSF/W-3a (13%,1.00)	SSF-4 (100%,1.00)			
Hypericum japonicum	WH-5 (17%,1.00)				
CONVOLVULACEAE					
Dichondra repens	SSF/W-3a (60%,1.00)	SSF-4 (100%,1.00)	SSF/W-6 (50%,1.00)		
**Ipomoea cairica*	SSF/W-5 (9%,1.00)	R/S/CS-4 (17%,3.00)			
Polymeria calycina	SSF/W-3a (60%,1.00)	SSF-4 (100%,1.00)			
DILLENIACEAE					
Adrastaea salicifolia	WH-5 (17%,2.00)				
Hibbertia dentata	SSF/W-2 (33%,1.50)				
Hibbertia fasciculata	WH-5 (17%,1.00)				
Hibbertia scandens	SSF/W-3a (20%,1.00)				
DROSERACEAE					
Drosera binata	SSF/W-2 (17%,1.00)	WH-5 (17%,1.00)			
Drosera spatulata	SSS-1a (100%,1.50)	SSS-1b (50%,1.00)	WH-5 (33%,1.00)		
EBENACEAE					
Diospyros pentamera	SSF-3c (100%,1.00)				
ELAEOCARPACEAE					
Elaeocarpus obovatus	SSF/W-3a (7%,1.00)	SSF-3c (100%,1.00)			

ERICACEAE					
Epacris microphylla var. *microphylla*	SSS-1b (50%,1.00)	WH-5 (33%,1.50)			
Epacris obtusifolia	SSS-1a (100%,1.00)	SSS-1b (100%,2.00)	WH-5 (83%,1.40)		
Epacris pulchella	SSF/W-2 (17%,1.00)	SSS-1a (50%,1.00)			
Leucopogon juniperinus	SSF/W-3a (7%,1.00)	SSF-4 (100%,1.00)			
Leucopogon lanceolatus var. *gracilis*	SSF/W-2 (50%,1.00)	SSF/W-3a (20%,1.00)			
Sprengelia incarnata	SSS-1a (50%,1.00)	WH-5 (50%,2.33)			
Sprengelia sprengelioides	SSS-1b (100%,1.00)	WH-5 (33%,1.00)			
Trochocarpa laurina	SSF/W-3a (7%,1.00)				
EUPHORBIACEAE					
Homalanthus populifolius	SSF/W-5 (9%,1.00)				
Pseudanthus orientalis	SSS-1a (50%,1.00)	SSS-1b (50%,1.00)	WH-5 (17%,1.00)		
FABACEAE - CAESALPINIOIDEAE					
**Senna pendula* var. *glabrata*	SSF/W-3a (7%,1.00)	SSF-3c (100%,1.00)	SSF/W-6 (50%,1.00)		
FABACEAE - FABOIDEAE					
Almaleea paludosa	SSS-1a (50%,1.00)				
Chorizema parviflorum	SSS-1a (50%,1.00)				
Desmodium brachypodum	SSF/W-2 (17%,1.00)				
Desmodium gunnii	SSF/W-3a (13%,1.00)				
Dillwynia floribunda	SSS-1a (100%,2.00)	SSS-1b (100%,1.50)	WH-5 (50%,1.67)		
Glycine clandestina	SSF/W-3a (33%,1.00)	SSF-4 (100%,1.00)			
Glycine microphylla	SSF/W-3a (13%,1.00)	SSF-4 (100%,1.00)	SSF/W-6 (50%,1.00)		
Gompholobium pinnatum	SSS-1a (100%,1.00)	WH-5 (17%,1.00)			
Kennedia rubicunda	SSF/W-2 (17%,1.00)	SSF/W-3a (60%,1.11)	SSS-2a (50%,1.00)	SSMW-2b (100%,2.00)	
Mirbelia rubiifolia	WH-5 (17%,1.00)				
Pultenaea blakelyi	SSF/W-2 (17%,2.00)	SSF/W-3a (7%,1.00)	SSF/W-3b (17%,1.00)	SSF-3c (100%,1.00)	
Pultenaea retusa	SSF/W-2 (17%,1.00)	SSF/W-3a (27%,1.00)			
Sphaerolobium minus	SSS-1a (100%,1.00)	WH-5 (17%,1.00)			
Sphaerolobium vimineum	WH-5 (17%,1.00)				
FABACEAE - MIMOSOIDEAE					
Acacia elongata	SSF/W-2 (67%,1.00)	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)	WH-5 (33%,1.00)	
Acacia irrorata	SSF/W-3a (13%,1.00)				
Acacia longifolia subsp. *longifolia*	SSF/W-2 (50%,1.00)	SSF/W-3a (27%,1.00)	SSF/W-3b (17%,1.00)	SSF/W-5 (18%,1.50)	SSS-2a (50%,2.00)
Acacia longifolia subsp. *sophorae*	WH-5 (17%,1.00)				
Acacia maidenii	SSF/W-3a (47%,1.14)	SSF/W-6 (50%,1.00)			
GENTIANACEAE					
Centaurium sp.	R/TG-7 (14%,2.00)	CS/TG-8 (9%,1.00)			
Centaurium spicatum	SSF/W-5 (9%,1.00)				
GERANIACEAE					
Geranium homeanum	SSF/W-3a (13%,1.00)				
GOODENIACEAE					
Dampiera stricta	SSS-1a (50%,1.00)	SSMW-2b (100%,1.00)	WH-5 (17%,1.00)		
Goodenia heterophylla subsp. *eglandulosa*	SSF/W-3a (7%,1.00)				
Goodenia ovata	SSF/W-3b (33%,1.00)	SSF/W-6 (50%,2.00)			
Goodenia paniculata	SSF/W-2 (17%,1.00)	SSF/W-3a (33%,1.20)	SSF/W-3b (17%,1.00)		
Goodenia sp.	R/S/CS-4 (17%,1.00)				
Goodenia stelligera	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)	WH-5 (33%,1.00)		

HALORAGACEAE					
Gonocarpus chinensis subsp. *verrucosus*	SSF/W-3a (20%,1.00)				
Gonocarpus micranthus	SSF/W-2 (17%,1.00)	SSF/W-3a (20%,1.00)	SSS-1a (50%,1.00)	WH-5 (17%,1.00)	
Gonocarpus salsoloides	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)			
Gonocarpus tetragynus	SSF/W-2 (50%,1.33)	SSF/W-3a (53%,1.13)	SSF/W-3b (17%,1.00)	SSF-4 (100%,1.00)	
Gonocarpus teucrioides	SSMW-2b (100%,2.00)				
LAMIACEAE					
Lycopus australis	SSF/W-3a (13%,1.00)				
LAURACEAE					
Cassytha glabella forma *glabella*	SSF/W-3a (7%,1.00)	SSF/W-5 (9%,1.00)	SSS-1a (100%,1.00)	SSS-1b (100%,1.00)	WH-5 (67%,1.25)
Cassytha pubescens	SSS-1b (50%,1.00)				
**Cinnamomum camphora*	SSF/W-3a (20%,1.00)				
Endiandra sieberi	SSF/W-3a (7%,1.00)	SSF/W-3b (17%,1.00)			
LENTIBULARIACEAE					
Utricularia australis	SSF-1 (100%,3.00)				
Utricularia gibba	SSF-1 (100%,1.00)	S-1 (33%,3.00)			
Utricularia lateriflora	SSS-1b (50%,1.00)				
LOBELIACEAE					
Isotoma armstrongii	SSF/W-3a (7%,1.00)				
Lobelia alata	SSF/W-3a (67%,1.00)	SSF/W-3b (100%,1.00)	SSF/W-5 (9%,2.00)	R/S-3 (20%,2.00)	R/TG-7 (5%,4.00)
Pratia purpurascens	SSF/W-3a (53%,1.13)	SSF-4 (100%,1.00)			
LOGANIACEAE					
Mitrasacme polymorpha	SSS-1a (50%,1.00)	WH-5 (17%,1.00)			
LORANTHACEAE					
Amyema cambagei	SSF/W-3a (7%,1.00)	SSF/W-3b (33%,1.00)	SSF/W-5 (9%,1.00)		
MALVACEAE					
**Sida rhombifolia*	SSF/W-6 (50%,1.00)				
MENISPERMACEAE					
Stephania japonica var. *discolor*	SSF/W-3a (20%,1.33)	SSF/W-6 (50%,1.00)			
MENYANTHACEAE					
Villarsia exaltata	SSF-1 (100%,1.00)	SSF/W-2 (50%,1.00)	WH-5 (17%,2.00)	S-6 (75%,2.00)	
Villarsia reniformis					
MORACEAE					
Ficus coronata	SSF/W-3a (7%,1.00)				
MYRTACEAE					
Angophora costata	SSF/W-3a (7%,1.00)				
Baeckea imbricata	SSS-1a (100%,1.50)	SSS-1b (100%,1.50)			
Callistemon citrinus	SSF/W-2 (17%,1.00)	SSS-1b (50%,3.00)	WH-5 (83%,1.40)		
Callistemon pachyphyllus	SSF/W-2 (17%,1.00)	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)	SSMW-2b (100%,2.00)	WH-5 (83%,1.60)
	S-6 (50%,1.50)				
Callistemon salignus	SSF/W-3a (53%,1.50)	SSF/W-3b (50%,1.33)	SSF-3c (100%,2.00)		
Corymbia maculata	SSF-4 (100%,1.00)				
Darwinia leptantha	SSS-1b (50%,2.00)	WH-5 (17%,2.00)			
Eucalyptus grandis	SSF/W-3a (27%,2.50)				
Eucalyptus microcorys	SSF/W-3a (7%,1.00)				
Eucalyptus propinqua	SSF/W-3a (7%,2.00)				
Eucalyptus resinifera	SSF/W-3a (7%,3.00)				
Eucalyptus robusta	SSF/W-2 (100%,3.17)	SSF/W-3a (67%,2.20)	SSF/W-3b (83%,2.20)	SSF-3c (100%,3.00)	SSS-1b (100%,1.00)
	SSS-2a (50%,2.00)	SSMW-2b (100%,4.00)			

Eucalyptus robusta X *tereticornis*	SSF/W-3b (17%,1.00)				
Eucalyptus siderophloia	SSF/W-3a (7%,1.00)				
Eucalyptus tereticornis	SSF/W-3a (20%,2.33)	SSF/W-3b (17%,1.00)	SSF-3c (100%,2.00)		
Leptospermum arachnoides	SSS-1a (100%,2.00)	SSS-1b (50%,2.00)	WH-5 (17%,1.00)		
Leptospermum juniperinum	SSF/W-2 (17%,1.00)	SSS-1a (50%,1.00)	SSS-1b (50%,1.00)	WH-5 (33%,1.50)	
Leptospermum liversidgei	SSF/W-2 (17%,2.00)	SSS-1a (50%,1.00)	SSS-1b (100%,2.00)	WH-5 (67%,3.75)	
Leptospermum polygalifolium subsp. *cismontanum*	SSF/W-2 (33%,1.50)	SSF/W-3a (13%,2.00)	SSS-1b (100%,2.50)	SSMW-2b (100%,3.00)	WH-5 (33%,1.00)
Leptospermum trinervium	SSF/W-2 (17%,1.00)				
Melaleuca ericifolia	SSF/W-3a (13%,1.50)	SSF/W-3b (33%,2.50)	SSF/W-5 (9%,1.00)	SSF/W-6 (50%,1.00)	SSS-2a (100%,5.00)
Melaleuca linariifolia	SSF/W-2 (67%,1.75)	SSF/W-3a (87%,2.31)	SSF/W-3b (83%,2.60)	SSF-3c (100%,3.00)	SSF-4 (100%,3.00)
	SSS-2a (100%,1.00)				
Melaleuca nodosa	SSF/W-3a (7%,4.00)	SSF/W-3b (17%,2.00)	SSF-4 (100%,5.00)	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)
	SSMW-2b (100%,2.00)				
Melaleuca quinquenervia	SSF-1 (100%,4.00)	SSF/W-2 (50%,3.00)	SSF/W-3a (87%,3.15)	SSF/W-3b (100%,3.83)	SSF/W-5 (45%,2.60)
	SSMW-2b (100%,1.00)	SSS-3 (100%,3.00)	R/S-3 (20%,1.00)	WH-5 (17%,1.00)	S-6 (25%,1.00)
Melaleuca sieberi	SSF/W-2 (33%,3.00)	SSF-4 (100%,1.00)	SSS-1a (100%,3.00)	SSS-1b (100%,1.50)	SSMW-2b (100%,1.00)
	WH-5 (17%,1.00)				
Melaleuca styphelioides	SSF/W-3a (53%,1.50)	SSF/W-3b (33%,2.50)	SSF-3c (100%,2.00)	SSF-4 (100%,2.00)	SSF/W-6 (100%,3.00)
Melaleuca thymifolia	SSF/W-2 (17%,3.00)	SSS-1a (100%,3.00)	SSS-1b (50%,1.00)	SSMW-2b (100%,1.00)	WH-5 (33%,3.00)
Syzygium smithii	SSF/W-3a (7%,2.00)				
OLACACEAE					
Olax stricta	SSMW-2b (100%,1.00)				
OLEACEAE					
Notelaea longifolia forma *intermedia*	SSF/W-3a (13%,1.50)				
ONAGRACEAE					
Ludwigia peploides subsp. *montevidensis*	S-1 (33%,1.00)	S/SG-2 (100%,1.00)			
OXALIDACEAE					
Oxalis exilis	SSF/W-3a (20%,1.00)	SSF-4 (100%,1.00)			
PHYLLANTHACEAE					
Breynia oblongifolia	SSF/W-3a (53%,1.00)	SSF-3c (100%,1.00)	SSF/W-6 (50%,1.00)		
Glochidion ferdinandi var. *ferdinandi*	SSF/W-3a (60%,1.56)	SSF/W-3b (33%,1.00)	SSF-3c (100%,2.00)		
Glochidion ferdinandi var. *pubens*	SSF/W-3a (47%,1.43)	SSF/W-3b (17%,2.00)	SSF-3c (100%,2.00)		
PITTOSPORACEAE					
Billardiera scandens	SSF/W-3a (13%,1.00)	SSF-4 (100%,1.00)			
Pittosporum revolutum	SSF-3c (100%,1.00)				
Pittosporum undulatum	SSF-3c (100%,2.00)				
PLANTAGINACEAE					
**Plantago lanceolata*	SSF/W-3a (7%,1.00)				
POLYGALACEAE					
Comesperma defoliatum	SSF/W-2 (17%,1.00)	WH-5 (17%,1.00)			
POLYGONACEAE					
Persicaria decipiens	SSF-3c (100%,1.00)	S-1 (33%,1.00)	S/SG-2 (50%,1.00)	R/S/CS-4 (17%,2.00)	
Persicaria dichotoma	SSF/W-3a (7%,1.00)				
Persicaria praetermissa	SSF/W-3a (7%,1.00)	S/SG-2 (100%,1.00)			
Persicaria strigosa	SSF/W-3a (7%,1.00)				

PRIMULACEAE					
Myrsine variabilis	SSF/W-3a (7%,1.00)				
Samolus repens	SSF/W-5 (36%,1.75)	SSF/W-6 (50%,3.00)	R/S/CS-4 (17%,1.00)	R/TG-7 (73%,2.44)	CS/TG-8 (64%,2.29)
PROTEACEAE					
Banksia aemula	SSMW-2b (100%,1.00)	WH-5 (17%,1.00)			
Banksia ericifolia subsp. *macrantha*	SSF/W-2 (17%,2.00)	SSS-1a (100%,1.50)	SSS-1b (100%,3.50)	WH-5 (83%,1.00)	
Banksia integrifolia subsp. *integrifolia*	SSF/W-3a (7%,1.00)				
Banksia oblongifolia	SSF/W-2 (17%,1.00)	SSS-1a (100%,3.50)	SSS-1b (100%,2.00)	SSMW-2b (100%,1.00)	WH-5 (50%,3.00)
Banksia robur	SSF/W-2 (33%,2.00)	WH-5 (17%,3.00)			
Banksia spinulosa var. *collina*	WH-5 (17%,1.00)				
Conospermum taxifolium	SSS-1a (50%,1.00)	WH-5 (17%,1.00)			
Hakea teretifolia subsp. *teretifolia*	SSF/W-2 (17%,1.00)	SSS-1a (100%,1.50)	SSS-1b (50%,1.00)	WH-5 (50%,2.67)	
Persoonia lanceolata	SSS-1b (100%,1.50)				
Persoonia levis	SSF/W-3a (7%,1.00)				
Persoonia linearis	SSF/W-3a (13%,1.00)				
Petrophile pulchella	SSS-1a (50%,1.00)	SSS-1b (50%,2.00)			
RANUNCULACEAE					
Ranunculus inundatus	SSF/W-3a (40%,1.00)	SSF/W-3b (17%,1.00)	R/S/CS-4 (17%,4.00)		
Ranunculus lappaceus	SSF/W-3a (13%,1.50)				
RHAMNACEAE					
Alphitonia excelsa	SSF/W-3a (13%,1.00)				
ROSACEAE					
Rubus moluccanus	SSF/W-3a (53%,1.00)				
RUBIACEAE					
Durringtonia paludosa	SSF/W-2 (50%,1.33)				
Galium binifolium	SSF/W-3a (13%,1.00)				
Galium propinquum	SSF/W-3a (7%,1.00)				
Morinda jasminoides	SSF/W-3a (13%,1.00)	SSF-3c (100%,1.00)			
Opercularia aspera	SSMW-2b (100%,2.00)				
Opercularia diphylla	SSF/W-3a (20%,1.00)	SSF-4 (100%,1.00)			
Opercularia varia	SSMW-2b (100%,2.00)				
Pomax umbellata	SSF/W-2 (17%,2.00)				
RUTACEAE					
Acronychia oblongifolia	SSF/W-3a (7%,1.00)	SSF-3c (100%,1.00)			
Boronia falcifolia	SSS-1a (50%,1.00)	SSS-1b (100%,1.50)	WH-5 (17%,2.00)		
Boronia parviflora	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)	WH-5 (33%,1.00)		
SANTALACEAE					
Exocarpos cupressiformis	SSF/W-5 (9%,1.00)				
Notothixos subaureus	SSF/W-3a (7%,1.00)	SSF/W-5 (9%,1.00)			
SAPINDACEAE					
Cupaniopsis anacardioides	SSF/W-3a (7%,1.00)	SSF/W-5 (18%,1.50)			
Guioa semiglauca	SSF/W-3a (7%,1.00)				
SCROPHULARIACEAE					
Bacopa monnieri	SSF/W-3a (13%,1.00)	SSF/W-5 (9%,1.00)	SSS-3 (100%,1.00)		
Mimulus repens	R/S-3 (20%,2.00)				
Myoporum acuminatum	SSF/W-5 (18%,1.00)	SSF/W-6 (50%,4.00)			
Veronica plebeia	SSF/W-3a (13%,1.00)				

SOLANACEAE					
Duboisia myoporoides	SSF/W-3a (20%,1.66)				
Solanum americanum	SSF/W-3a (7%,1.00)	SSF/W-6 (50%,1.00)			
**Solanum mauritianum*	SSF/W-3a (20%,1.00)				
Solanum prinophyllum	SSF/W-3a (20%,1.00)	SSF/W-5 (9%,1.00)	SSF/W-6 (50%,1.00)		
STACKHOUSIACEAE					
Stackhousia nuda	SSS-1a (100%,1.00)				
STYLIDIACEAE					
Stylidium graminifolium	WH-5 (17%,1.00)				
THYMELAEACEAE					
Pimelea linifolia	SSF/W-2 (17%,1.00)	SSF/W-3a (13%,1.00)	SSS-1a (50%,1.00)	SSS-1b (50%,1.00)	WH-5 (33%,1.00)
Wikstroemia indica	SSF/W-3a (7%,1.00)				
VERBENACEAE					
**Lantana camara*	SSF/W-3a (47%,1.57)	SSF-3c (100%,1.00)	SSF/W-6 (100%,1.00)		
**Verbena bonariensis*	SSF/W-3a (7%,1.00)				
VIOLACEAE					
Hybanthus stellarioides	SSF-4 (100%,1.00)				
Viola banksii	SSF/W-3a (100%,1.87)	SSF/W-3b (50%,1.00)	SSF/W-5 (18%,1.00)	SSF/W-6 (100%,3.00)	SSS-2a (50%,1.00)
	R/S/CS-4 (17%,2.00)				
VITACEAE					
Cayratia clematidea	SSF/W-6 (50%,1.00)				
Cissus antarctica	SSF/W-2 (17%,1.00)				

New South Wales Vegetation Classification and Assessment: Part 2 Plant communities of the NSW South-western Slopes Bioregion and update of NSW Western Plains plant communities, Version 2 of the NSWVCA database

J.S. Benson

Science and Public Programs, Royal Botanic Gardens and Domain Trust, Sydney, NSW 2000, AUSTRALIA.
Email: john.benson@rbgsyd.nsw.gov.au

Abstract: This third paper in the NSW Vegetation Classification and Assessment series covers the NSW South-western Slopes Bioregion of 8.192 million hectares being 10% of NSW. A total of 135 plant communities, comprising 97 new communities and 38 previously described communities, are classified. Their protected area and threat status is assessed. A full description of the 135 plant communities is provided in a 400 page report, generated from the NSWVCA database, on the CD accompanying this paper. *Eucalyptus*-dominated grassy or shrubby woodlands and open forests are the main types of vegetation in the bioregion. The CD also contains a read-only version of Version 2 of the NSWVCA database that includes updated information on the plant communities previously published in Version 1 of the NSWVCA covering the NSW Western Plains. Six new communities are added to the Western Plains. The vegetation classification and assessment is based on published and unpublished vegetation surveys and map unit descriptions that are listed in the NSWVCA Bibliography on the CD, expert advice and extensive field checking.

Over 80% of the native vegetation in the NSW South-western Slopes Bioregion has been cleared making it the most cleared and fragmented of the 18 IBRA Bioregions in NSW. Exotic plant species dominate the ground cover outside conservation reserves, state forests, roadsides and travelling stock reserves. As of September 2008 about 1.9% of the Bioregion was in 105 protected areas and 28 of the 135 plant communities were assessed to be adequately protected in reserves. Using NSWVCA Threat Criteria, 18 plant communities were assessed as being Critically Endangered, 33 Endangered, 29 Vulnerable, 25 Near Threatened and 30 Least Concern. Current threats include over-grazing, especially during drought, exotic species dominance of the ground cover, impacts of fragmentation on species persistence and genetic diversity and impacts of lower rainfall due to climate change.

To address these threats, linking and enlarging vegetation remnants through revegetation (including regenerating native ground cover) is required. Some progress is being made through re-vegetation schemes driven by the NSW 2003 Natural Resource reforms, however, more incentive funding for landholders would accelerate the re-vegetation program.

***Cunninghamia* (2008) 10 (4): 599–673**

Introduction

This is the third paper in the New South Wales Vegetation Classification and Assessment (NSWVCA) project that aims to finely classify and assess the status of plant communities in New South Wales (NSW). The paper and its accompanying CD provide a detailed classification and assessment of the native vegetation in the New South Wales South-western Slopes Bioregion (NSWSWS Bioregion) defined in IBRA Version 6 of Thackway & Cresswell (1995).

Benson (2006) contains a history and description of vegetation classification internationally, in Australian and in NSW; descriptions of the parameters of the NSWVCA project; descriptions of the NSWVCA database fields, reports and software; descriptions of the protected area assessment rules and threat criteria used to assign protected area adequacy and threat categories to the classified plant communities. Benson (2006) includes a number of figures showing planning regions in NSW, including bioregions and catchment management authority areas (CMAs). These figures should be referred to when reading this paper.

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Benson et al. (2006) contains Version 1 of the NSWVCA database with 213 plant communities classified and described for the eight western-most NSW IBRA bioregions that comprise the semi-arid and arid NSW Western Plains covering 57% of NSW. The completion of the NSWVCA for the NSWSWS Bioregion, reported here, in addition to the NSW Western Plains, means that 53 million hectares or 65% of NSW have been covered by a consistent and detailed vegetation classification and plant community status assessment (Figure 1).

As outlined in Benson (2006), the project builds on the Australian vegetation classification of Beadle (1981) using existing analyses of floristic site data, vegetation map unit descriptions, vegetation reports, expert knowledge and field checking to classify and assess the status of native vegetation. Extensive field surveys were used to check previous classifications and help to gap fill where data were lacking. The hierarchical level of the vegetation classification generally conforms to the "plant association" or sub-association" levels defined in Beadle & Costin (1952) or Levels 5/6 in the National Vegetation Information System (NVIS) (ESCAVI 2003). While the NSWVCA classification is mainly based on floristic variation, abiotic factors such as substrate and soil have been taken into account in defining the plant communities (Benson 2006).

The NSWVCA is assisting environmental site assessment with its classified plant communities progressively being incorporated into the Biometric Tool in the NSW Property Vegetation Planning process (Gibbons et al. 2005). It should be useful for setting priorities in national, state, regional or local planning targets and for setting priorities for new conservation reserves or secure property agreements to fulfil a comprehensive, representative protected area system in NSW. The inputs, products, uses and outcomes of the NSWVCA project are summarised on the flow diagram in Figure 2.

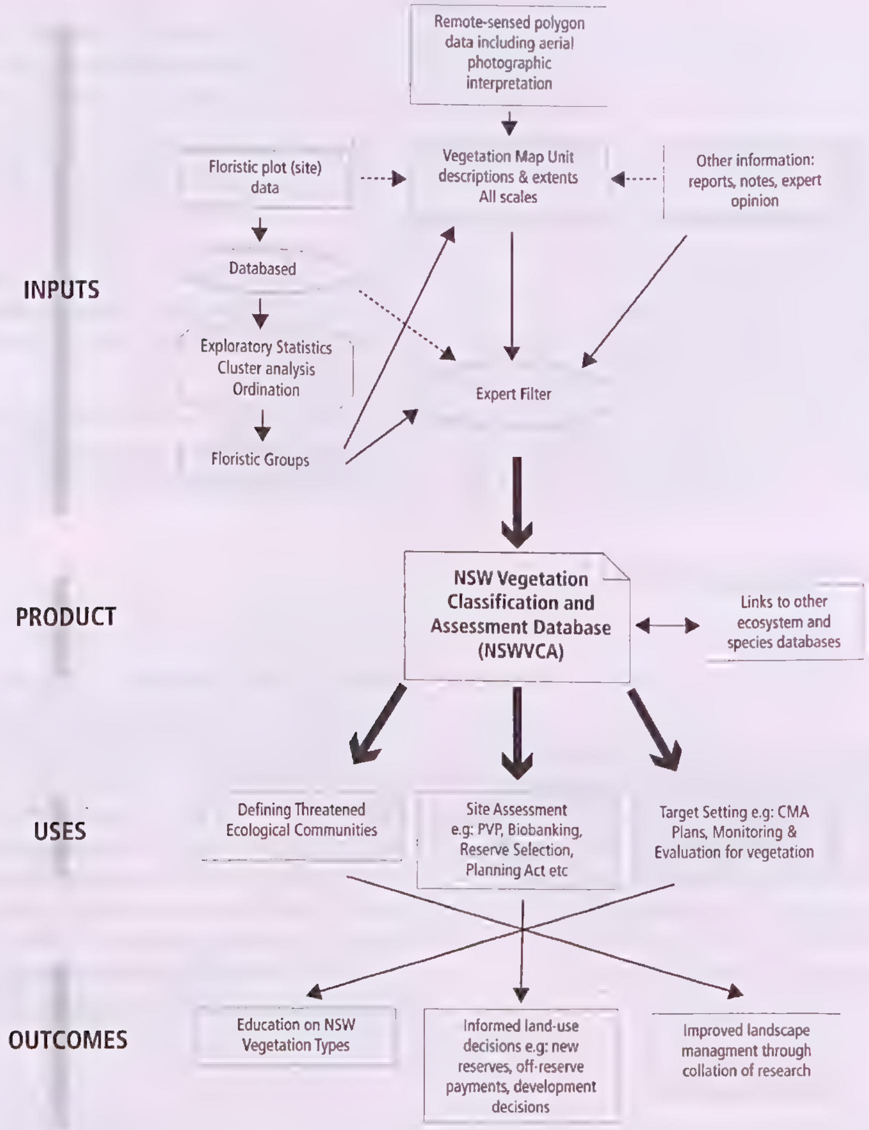

Remote-sensed polygon data including aerial photographic interpretation
Floristic plot (site) data
Vegetation Map Unit descriptions & extents All scales
Other information: reports, notes, expert opinion
INPUTS
Databased
Exploratory Statistics Cluster analysis Ordination
Expert Filter
Floristic Groups
PRODUCT
NSW Vegetation Classification and Assessment Database (NSWVCA)
Links to other ecosystem and species databases
USES
Defining Threatened Ecological Communities
Site Assessment e.g: PVP, Biobanking, Reserve Selection, Planning Act etc
Target Setting e.g: CMA Plans, Monitoring & Evaluation for vegetation
OUTCOMES
Education on NSW Vegetation Types
Informed land-use decisions e.g: new reserves, off-reserve payments, development decisions
Improved landscape managment through collation of research

Fig. 2. Flow diagram showing the data and expert inputs to product the NSWVCA product, its uses and prospective outcomes.

The CD accompanying this paper (back pocket of the journal) contains the descriptions of the plant communities in the NSW South-western Slopes Bioregion and updated information on the plant communities previously described for the NSW Western Plains (Benson et al. 2006). The CD also contains a read only version of Version 2 of the NSWVCA database.

The study area: NSW South-western Slopes Bioregion

The NSW South-western Slopes Bioregion includes 8,191,970 hectares, being 10.2% of the area of NSW (Figures 1 & 3). It includes an area from the Victorian border east of Albury in the south to the town of Dundedoo in the north being bounded in the east by the cooler and moister South Eastern Highlands Bioregion and in the west by the drier and hotter NSW Western Plains. From north to south the NSWSWS Bioregion includes the major inland towns of Wellington, Mudgee, Parkes, Forbes, Cowra, West Wyalong, Temora, Boorowa, Cootamundra, Narrandera, Wagga Wagga, Tumut and Albury.

The Bioregion includes the South Western Slopes and most of the Central Western Slopes Botanical Divisions defined in Anderson (1961). Its western boundary abuts the Riverina and Cobar Peneplain Bioregions, its northern boundary abuts the Darling Riverine Plain and Brigalow Belt South Bioregions and its eastern boundary abuts the Sydney Basin and South Eastern Highlands Bioregions.

The NSWSWS Bioregion includes the mid-sections of the Murray, Murrumbidgee, Lachlan and Central West Catchment Management Authority areas (CMAs) that run westwards (inland) from the Great Dividing Range (Figure 3). A total of 25 Local Government Areas (LGAs) are fully or partly within the NSWSWS Bioregion.

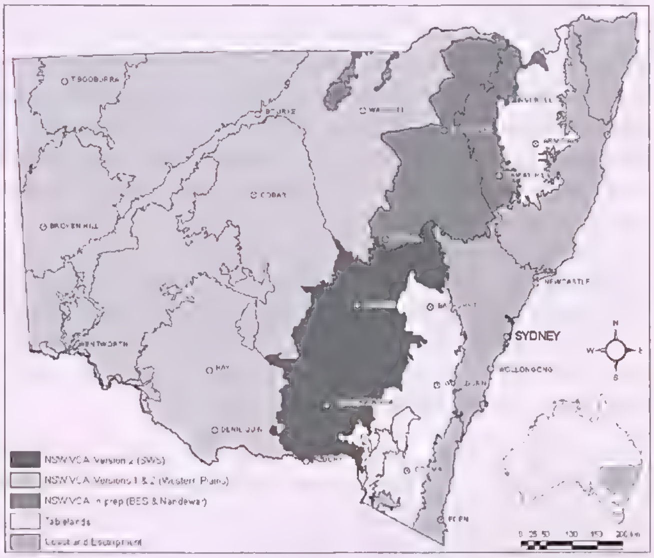
A comprehensive summary of abiotic and biotic features in the NSWSWS Bioregion is available in a scoping study report produced by NSW National Parks and Wildlife Service (NPWS)(2001).

Climate

The NSWSWS Bioregion includes two of the nine Australian climate zones defined by Stern (2000) (see Figure 3 in Benson 2006) that cover NSW. These are the Temperate – No Dry Season (hot summer) climate zone that is more or less congruent with the Lower Slopes Sub-region and the Temperate – No Dry Season (warm summer) climate zone that is more or less congruent with the Upper Slopes Sub-region. Mean annual rainfall varies from over 800 mm at Tumut in the east of the Bioregion to 470 mm at Condobolin in the western side of the bioregion (NSW NPWS 2003). Maximum annual average monthly temperatures range from 24° to 33° C and minimum annual average monthly temperatures range from -0.7° to 3.2°C (NSW NPWS 2003). Typical mean daily temperatures of some towns are: 24° at Dubbo, 21° at Albury and 23° at Mudgee.

Physiography

The physical characters of the NSWSWS Bioregion are summarised in NSW NPWS (2003) and NSW NPWS (2001). Moore (1953a) describes the climate, geology and soils of the southern two thirds of the area including the relationships of these abiotic factors with vegetation types. Detailed descriptions and maps of soil landscapes are provided in King (1989) for the Forbes 1:250,000 map sheet and in Chen & McKane (1996) for the Wagga Wagga 1:100,000 map sheet.


SYDNEY
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W
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NSWVCA Version 2 (SWS)
NSWVCA Versions 1 & 2 (Western Plains)
NSWVCA in prep (BBS & Nandewar)
Tablelands
Coast and Escarpment

Fig. 1. Progress of the NSWVCA project across New South Wales, Australia. Version 1 (Benson et al. 2006) covered the NSW Western Plains. Version 2 updates the NSWVCA for the NSW Western Plains and includes extra plant communities occurring in the NSW South-western Slopes Bioregion (NSWSWS) (this volume). Version 3 will add the Brigalow Belt South and Nandewar Bioregions to the NSWVCA.

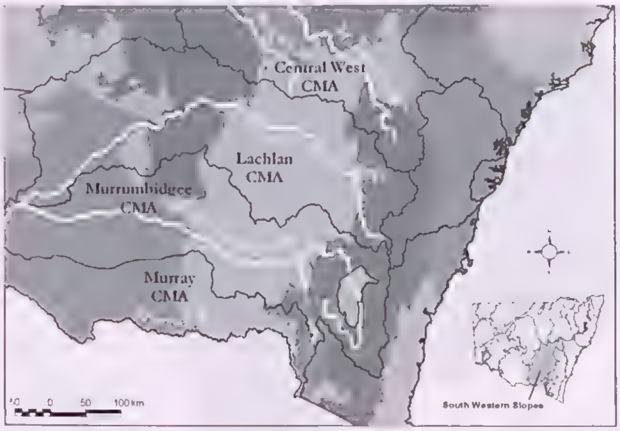

Fig. 3. The 8 million hectare NSW South-western Slopes Bioregion showing major rivers and the location of four Catchment Management Authority areas (CMAs) that intersect the bioregion.

The NSWSWS Bioregion is divided into the Lower Slopes and Upper Slopes Sub-regions (DEC NSW 2004) (Figure 4). These sub-regions contain contrasting substrates, soils and vegetation. The landform patterns in the Lower Slopes sub-region are dominated by flood plains, alluvial plains and terrace plains with some isolated rocky hills. Overall, alluvial deposits cover 33% of the whole NSWSWS Bioregion (NSW NPWS 2001). Typical soils in the Lower Slopes Sub-region include alluvial brown, grey and red clays, clay-loams and red or black earths (loams). Gilgai soils have developed on some low lying plains with heavy clay soils such as at Bullenbong Plain near Lockhart and near Albury.

Aeolian sand to loam soil occurs on rises near major rivers or on sand plains that over-top alluvial sediments. Fine aeolian loam or clay soils (parna) occur from Temora in the north extending to south of Wagga Wagga in the south. Shallow, gravel soils occur on low rises composed of sedimentary sandstones, ironstone or metamorphic rocks. Skeletal sandy lithosol soils occur on rocky hills or ranges composed of siliceous rocky substrates such as sandstone and granite, although this type of terrain is limited in extent in the Lower Slopes Sub-region.

Lakes occur in the Lower Slopes Sub-region west of Forbes (Nerang Cowal, Lake Cowal), to the south of Wagga Wagga near Walla Walla (for example Gum Cowal) and in the far south-west of the bioregion such as Lake Urana. The beds of these lakes contain grey clay soil.

The Upper Slopes Sub-region contains more complex geological and soil compositions influenced by the major geological feature – the Lachlan Fold Belt (Gray 1997). The main landform patterns are hills with small areas of floodplains and alluvial plains along major river valleys. The hills are very steep in places. Substrate includes sedimentary, metamorphic, volcanic rocks, igneous rocks with fine-grained sedimentary rocks including shale and mudstone (NSW Department of Mines 1970). Common metamorphic rocks include slate and phyllite. The siliceous metamorphic rock quartzite commonly outcrops on the crests of hills throughout the Upper Slopes Sub-region.

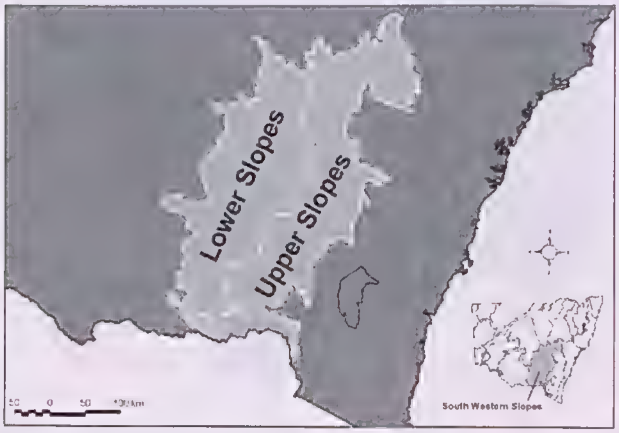

Fig. 4. Lower Slopes and Upper Slopes Sub-regions within the NSW South-western Slopes Bioregion.

North-south orientated strike ridges are primarily composed of sandstone. Some hills are composed of conglomerate, such as near Reefton in the mid-north, Benambra in the south and Mount Arthur near Wellington in the north (pers. obs). Limited outcrops of limestone occur, the most famous being at Wellington Caves (Osborne 1998). Fine-grained sedimentary rocks such as shale and mudstone are common in the upper Macquarie River valley and in the region from Mudgee to Wellington in the far north of the bioregion. Acid volcanic rocks (mainly rhyolite) outcrop on hills north of Boorowa including at Wyangala Dam and on the Hervey and Currumbena Ranges near Peak Hill (including part of Goobang National Park) in the northern part of the bioregion (NSW Department of Mines 1971, 1972).

Various types of granite outcrop on the hills between Albury – Wagga – Tumbarumba in the south, on the Boginderra Hills near Temora and at Eugowra east of Forbes in the north NSW Department of Mines 1971). Granodiorite occurs near Tumbarumba on the south-eastern edge of the bioregion. Quartz-rich adamellite outcrops just north of Tumut (including in Mudjarn Nature Reserve) and near Kyeamba.

The main soil types in the Upper Slopes Sub-region are yellow and red podsolic (texture contrast) soils, red or brown solodic soils derived from sedimentary or acid volcanic (rhyolite) rocks along with yellow earths and red earths (Chen & McKane. 1996). Lithosol soil is common on rocky hills.

Small areas of Tertiary basalt in the Upper Slopes Sub-region form dark (chocolate) loam (or black earth) soils. Quaternary alluvium composed of gravels, sands and loams occur along river valleys. Colluvium occurs on outwashes at the base of hills. Organic or peaty soils have developed in some valleys where sediment has accumulated and water flow has been impaired, sometimes forming swamps. Wetlands occur in old river channels or in depressions on the floodplains of the Murray, Murrumbidgee and Lachlan Rivers.

One of the largest areas of serpentinite rocks in NSW outcrop between Cootamundra – Coolac – Tumut in the south-eastern part of the bioregion (Ashley et al. 1971). The serpentinite-derived soil supports distinctive vegetation exhibiting unusual structure and species composition (Lyons et al. 1974).

Land use and land degradation

The Aboriginal and European occupation history of the NSWSWS Bioregion is summarised in NSW NPWS (2003). Most of the area north of the Murrumbidgee River was occupied by Wiradjuri people. The Yorta Yorta people occupied the Murray River region. By the 1850s Aboriginal culture had been severely disrupted by the impacts of European land settlement, disease and direct confrontation.

John Oxley was the first European explorer to traverse the northern section of the NSWSWS Bioregion in 1817 and Charles Sturt crossed the southern part of the Bioregion in 1827. Shortly after, settlers arrived with livestock and radical changes to the native vegetation of the bioregion commenced. Gold rushes to central NSW during and after the 1850s lead to a rapid growth in the European population and increases in pastoral production. Currently, a large gold mine is in production at Lake Cowal, west of Forbes.

The NSWSWS Bioregion is now one the most intensively farmed regions in Australia with 96% of the area freehold land (NSW NPWS 2001). During the last 50 years large areas of grazing land has been converted to irrigated and dryland cropping. Irrigation for pasture and horticultural crops such as stone fruit and grapes occurs on rich alluvial flats and adjoining hills near to the major rivers. Dryland cropping of wheat, barley and rape seed occupy a high proportion of the Lower Slopes Sub-region and a smaller part of the Upper Slopes Sub-region.

Today, over 80% of the woody cover of native vegetation has been cleared (Figure 5) (Benson 1999, Pressey et al. 2000, Keith & Simpson 2008). Most of the uncleared native vegetation has been heavily grazed and this has impacted on species composition and vegetation structure. Sheet and gully soil erosion is common on steep hills in the Upper Slopes Sub-region, while sheet and wind erosion have impacted the soils of the alluvial plains in the Lower Slopes Sub-region. Salinity affects at least 93,000 ha of land in the bioregion (Littleboy et al. 2001 cited in NSW NPWS 2001).

An expansion of the use of exotic pasture and fertiliser since World War II has lead to a dominance of exotic grasses and forbs in the ground cover over most of the bioregion (Prober 1996). This limits the potential for restoration in these landscapes. Very few large areas of native vegetation remain on high fertile soils in valleys or on alluvial plains. The largest and most intact native vegetation remnants occur on low nutrient soils on steep hills or rocky ranges (NSW NPWS 2001). Smaller patches of grassy woodland remnants occur on travelling stock routes and roadsides. Small areas of forests and woodlands on aeolian sandy-loam soils, containing stands of the valuable timber tree White Cypress Pine (*Callitris glaucophylla*), were protected in forest preserves in the late 19th Century and early 20th Century. Many of these later became State Forests under the NSW Forestry Act 1916 and some have since been transferred to conservation reserves under the NSW National Parks and Wildlife Act 1974.

Less than 2% of the Bioregion is in protected areas including various types of conservation reserves and secure property agreements. In addition to protected areas only about 1.5% of the bioregion is State Forest and less than 1% is held in other public ownership such as travelling stock reserves and road reserves, therefore, only 4 to 5% of the NSWSWS Bioregion is in public ownership. With the exception of the 42,000 ha Goobang National Park near Peak Hill and the 24,000 ha Woomargama National Park near Holbrook, most of the native vegetation remnants and conservation reserves are tiny in size. This is demonstrated in the analysis of native vegetation patch sizes by Gibbons & Boak (2002) for the Holbrook region (just north of Albury) where the vast majority of patches were found to be less than 10 ha in size.

Another impact on native vegetation and natural corridor links has been a large expansion of pulp and timber exotic pine plantations (*Pinus radiata*) in the Tumut to Tumbarumba district in the south-eastern corner of the NSWSWS Bioregion.

Previous botanical studies

Moore (1953a) describes the vegetation of the southern half of the NSWSWS Bioregion (south of the town of Young) in a vegetation classification hierarchy similar to the scheme developed by Beadle & Costin (1952). His coarse-scale (1:500,000) vegetation map depicts the pre-European distribution of 10 broadly classified "alliances". The diagrammatic relationship of the environmental variables soil and climate with vegetation type presented on page 522 in Moore (1953a) remains relevant today. In a complementary paper, Moore (1953b) discussed "disclimax" communities of the region in relation to proposed "original" vegetation.

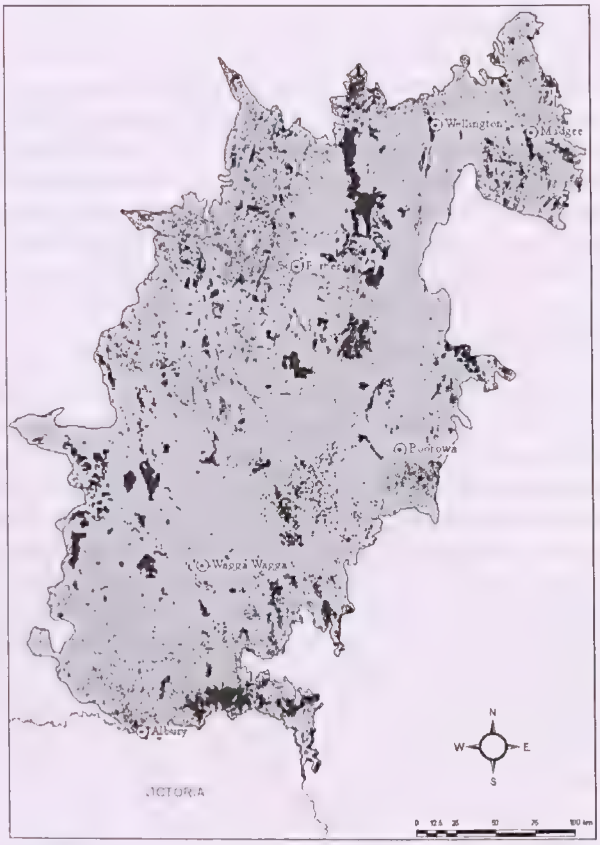

Fig. 5. Map showing cleared areas (light grey) and woody native vegetation remnants (black) in the NSWSWS Bioregion. Source: Keith & Simpson (2008).

After Moore's 1950s contributions, there was a hiatus in botanical survey and vegetation mapping in the NSW SWS Bioregion. However, since 1990 a number of botanical surveys have been undertaken and a number of vegetation maps have been produced. Some of these cover large areas such as a topographical map sheet area or a local government area but most cover smaller areas such as conservation reserves.

One of the first plot based vegetation surveys in the bioregion was the 1:250,000 vegetation mapping of the southern NSW wheatbelt covering the Forbes and Condobolin 1:250,000 map sheet areas by Sivertsen & Metcalfe (1995). This describes and maps major vegetation types in the central-western part of the Bioregion. Bos & Lockwood (1996) provide a floristic classification based on plot sampling of State Forests and some other areas in the southern half of the Upper Slopes Sub-region of the bioregion between Forbes and Albury. Austin et al. (2000) modelled 77 floristic groups across environmental gradients in the central Lachlan River region using over 1000 records of canopy and perennial shrub species. While this provided limited description of the full plant species composition of the vegetation, it provided an insight to the main canopy species groupings in that region.

As part of the NSW Native Vegetation Mapping Program (2000–2005), Lewer et al. (2003) plot sampled and mapped native vegetation over six 1:100,000 scale map sheet areas on the north-western edge of the Bioregion extending into the eastern edge of the adjoining Cobar Peneplain Bioregion. Of these six maps, the Tullamore, Tottenham and Bogan Gate 1:100,000 map sheets are in the NSW SWS Bioregion. This finer scale mapping covered part of the previous 1:250,000 scale mapping in Sivertsen & Metcalfe (1995). Lewer et al. (2003) describe 61 floristic groups (20 of which are non-woody) from analysis of plot data. These groups were lumped into 27 map units. Some of these floristic groups and map units are mainly distributed outside the NSW SWS Bioregion and have previously been collated into the NSWVCA for the NSW Western Plains section (Benson et al. 2006).

Seddon et al. (2002) document the vegetation of the Little River catchment in the Central West CMA in the far northern part of the NSW SWS Bioregion. This includes modelling pre-European extent of vegetation types. To the west of Little River, Porteners (1997) produced a detailed vegetation map and vegetation classification of the extensive Goobang National Park that includes parts of the Hervey and Currumbena Ranges near Peak Hill. A number of distinct vegetation types are confined to that region. Subsequently, Porteners (2001) surveyed and mapped the vegetation in Big Brush, Ingalba and Pucawan Nature Reserves near Temora in the Lower Slopes Sub-region. To the north west of these three reserves, Lilley & Tidemann (1994) documented the vegetation in Buddigower Nature Reserve near West Wyalong. Most recently, Porteners (2007) mapped and described the plant communities in Koorawatha, Dananbilla, Gungewalla and Illunie Nature Reserves between Boorowa and Cowra in the Upper Slopes Sub-region.

East of Goobang NP, the conservation reserves Nangar, Weddin Mountains and Conimbla National Parks were surveyed and mapped by ERM Mitchell McCotter (1996). Lembit & Skelton (1998) mapped and surveyed Barton, Copperhannia and Dapper Nature Reserves on the north-eastern boundary of the NSW SWS Bioregion They also mapped Boginderra Hills Nature Reserve near Temora in the Lower Slopes Sub-region. Hill & Peake (2000) mapped and surveyed the Avisford Nature Reserve, near Mudgee, at the north-eastern tip of the NSW SWS Bioregion. The vegetation in the Mudgee part of the NSW SWS Bioregion intergrades with vegetation types more typical of the Sydney Basin and Brigalow Belt South Bioregions.

Gellie (2005) produced a forest ecosystem classification for the south-east corner of NSW including the southern part of the Upper Slopes Sub-region of the NSWSWS Bioregion. The classification was based on analysis of floristic site data and resulting floristic groups were mapped through modelling. A site specific vegetation survey and on-ground aerial photographic mapping exercise was completed by Gellie & Fanning (2004). This produced a detailed floristic classification and fine-scale vegetation maps of 14 conservation reserves in the NSWSWS Bioregion. The reserves were Benambra National Park (NP), Courabyra Nature Reserve (NR), Downfall NR, Ellerslie NR, Livingstone NP, Livingston State Conservation Area (SCA), Minjary NR, Mudjarn NR, Nest Hill NR, Tabletop NR, Tumblong SCA, Ulandra NR, Wereboldera SCA and Woomargama NP. A supplementary survey by Gellie (EcoGIS 2005) sampled and mapped the vegetation in Bogandyera, Clarkes Hill and Jingellic Nature Reserves in the upper Murray River catchment. The combined survey and mapping in Gellie & Fanning (2004) and EcoGIS (2005) cover the most complex array of vegetation types in the NSWSWS Bioregion – a complexity reflecting the Albury to Yass region's rugged topography, substrate variation and relatively high rainfall.

Unpublished NSW NPWS file notes describe vegetation in some conservation reserves and NSW State Forests has produced Forest Type maps for most of the State Forests in the Bioregion including areas dedicated as Flora Reserve under the Forestry Act 1916. A detailed account of the forest history for three White Cypress Pine (*Callitris glaucophylla*) – dominated State Forests in the Forbes region is provided in Allen (1998).

Priday (2004) produced a fine-scale vegetation map of the Wagga Wagga Shire largely based on substrate. The Boorowa Shire, situated in the Upper Slopes Sub-region, was sampled and mapped into broad vegetation units by NSW NPWS (2002). Priday (incomplete 2006) produced a biolandscape vegetation classification covering the southern half of the NSWSWS Bioregion emphasising substrate in the ecological classification.

To meet some interim planning needs of the Lachlan and Central West Catchment management Authorities, DEC NSW (2006, 2006a) produced 1:250,000 scale maps depicting broadly typed vegetation communities in these two catchment areas. While this mapping did not include plot sampling, it included aerial photographic interpretation of some previously unmapped areas and rapid ground checking of areas lacking existing map or plot data.

Wetlands downstream (westwards) of the Hume Reservoir on the Murray River were classified on hydrological features and mapped by Pressey (1986). The *Eucalyptus camaldulensis* (River Red Gum), *Eucalyptus largiflorens* (Black Box) and other floodplain plant communities on the Murray River west of Albury were mapped by Margules & Partners (1990) and floristically classified by Smith & Smith (1990). Webster & Davidson (2003) have produced an inventory of floodplain wetlands in the upper Murray (east of Albury) and mid-upper Murrumbidgee River floodplains. Webster (2007) subsequently produced a management history of some of the upper Murray River wetlands.

Most conservation reserves in the NSW SWS Bioregion have now been mapped and/or plot sampled. Since these reserves occupy topographically and geologically diverse landscapes in ranges and hills, the more complex mosaics of vegetation types have been sampled and documented. Vegetation mapping and sample plot data outside conservation reserves remains poor. Based on the relationships between vegetation heterogeneity and landscape heterogeneity it is likely that the vegetation in these areas was probably more homogenous due to large areas of similar soil types where grassy box woodlands would have occurred.

Gibbons & Boak (2002) produced a study on isolated trees and patch sizes of different vegetation types in the Holbrook area in the southern part of the NSW SWS Bioregion. Their findings have implications for threat assessment and vegetation management discussed below.

Educational booklets containing detailed notes on vegetation types and their species composition have been produced for the vegetation of the upper Murray / Murrumbidgee River catchments by Stelling (1998) and for the mid-Lachlan River region by the now defunct Mid-Lachlan Regional Vegetation Committee (1999).

In summarising, irrespective of the early vegetation survey and mapping by Moore (1953), the biogeographical approach by Priday (2006), surveys of conservation reserves and some local government areas, there has been no consistent mapping or description of vegetation types across the whole NSWSWS Bioregion. Sound plot data exists for most reserves but are scarce for private land. This mirrors the vegetation data situation in the NSW Western Plains reported in Benson et al. (2006). Therefore, additional plot data sampling all landscapes, data analyses and regional, fine scale vegetation mapping could refine this initial vegetation classification.

The vegetation classification

A discussion on methods used to classify vegetation for the NSWVCA is outlined on pages 341–344 in Benson (2006). These include collation and cross-checking of all available vegetation surveys, vegetation mapping, floristic site data and extensive field checking. All sources, including map unit or floristic group names or numbers used to define each plant community, are cited in the "Authority" field in the NSWVCA database. These references are included in the Reference field of each plant community record in the database and are listed in the NSWVCA Bibliography in a spreadsheet on the CD accompanying this article.

The vegetation classification is based on floristic criteria taking into account physiognomic features. The classification places an emphasis on the numerically classified floristic groups from relevant regional and local vegetation survey projects. Available cluster analysis outputs were examined when deciding on species groups, and individual project authors were contacted to discuss whether to combine or split their floristic groups for a State project. These decisions are documented in the Authority field of the database. As large parts of the NSW SWS Bioregion were found to be deficient in quantitative floristic data, I derived some of the plant communities from map descriptions, species lists, field checking or other qualitative information.

The characteristic species listed in the three Characteristic Species strata fields in the database were mainly based on dominant species derived from plot data analyses or from field observations. Diagnostic species, defined in fidelity analyses (*sensu* Westhoff & Van der Maaral 1980), may also be listed. However, diagnostic species in vegetation classifications cannot necessarily be solely relied on to define boundaries between similar communities (Chytrý et al. 2002). The NSWVCA database does not presently contain a "fidelity" field for registering diagnostic species but such a field could be added.

Confidence ratings in the "Classification confidence level" field in the database reflect the quality of data supporting each plant community definition. A number of the plant communities are registered with a low-medium confidence rating due to a lack of data. This includes plant communities where expert opinion suggested they exist but site data was lacking to improve their definition and description.

Six field trips to ground truth communities were undertaken (April 2002, October 2002, May 2005, April–May 2006, February 2007 and May 2007) (Figure 6). Vegetation was checked at over 300 field stops, made during approximately 10,000 km of road traverse that included most major and minor roads and most conservation reserves. At each field stop dominant plant species and physiographic data were recorded in a notebook and a GPS site recording was taken. Copies of the notebooks are held by the Botanic Gardens Trust, Sydney.

The vegetation in most of the conservation reserves in the bioregion was field-checked. Botanical surveys and large-scale vegetation mapping in these reserves greatly assisted with the NSWVCA classification in the upper Murray and mid-Murrumbidgee River regions in the southern part of the bioregion and around the towns of Peak Hill and Mudgee in the northern part of the bioregion.

Each plant community was assigned a protected area adequacy code based on the threshold rules outlined in field 79 in Appendix A in Benson (2006). Similarly, each community is assigned a threat code based on the threat criteria outlined in Appendix B in Benson (2006). The combined protected area/threat code succinctly summarises the status of each community.

Recognition of NSWVCA plant communities for use in field site or office assessments will largely require comparison of characteristic species including diagnostic species with high fidelity, physiographic features such as soil type and landform pattern and geographical location. A comprehensive discussion on the topic field recognition of vegetation type, is given for the United States National Vegetation Classification in Jennings et al. (2006).

The NSWVCA database contains a query mode and search routine that can be used for listing candidate plant communities for a site assessment. Spatial context is provided through the database report options that allow communities to be listed by IBRA Bioregions, bioregion sub-regions, Local Government Areas and other types of geographical areas. The query mode, which is accessible in the non-read only version of the database, facilitates complex multi-field queries such as listing plant communities from a number of types of geographical areas combined with a number of the other 90 database fields. If in the future links can be constructed between the database and maps of plant communities, the spatial capacity of the NSWVCA will improve. It is proposed that future vegetation mapping in NSW, in regions covered by the NSWVCA, will refer map unit classifications to those in the NSWVCA (pers. comm., DECC NSW Vegetation Information System, in development). A matrix-like key to the plant communities would assist with filtering plant communities in database searches for regional or site assessments. Such a key would likely use database fields such as characteristic species, geographical location, abiotic variables and photographs (see future progress section below).

Estimates of extent

The methods for estimating pre-European extent, current extent and extent in protected areas are outlined in Benson (2006) and Benson et al. (2006). All available vegetation maps were interrogated using geographical information (GIS) software. Accurate estimates (within 10% error) are provided for extent in many of the protected areas. However, because contextual vegetation mapping is lacking for the

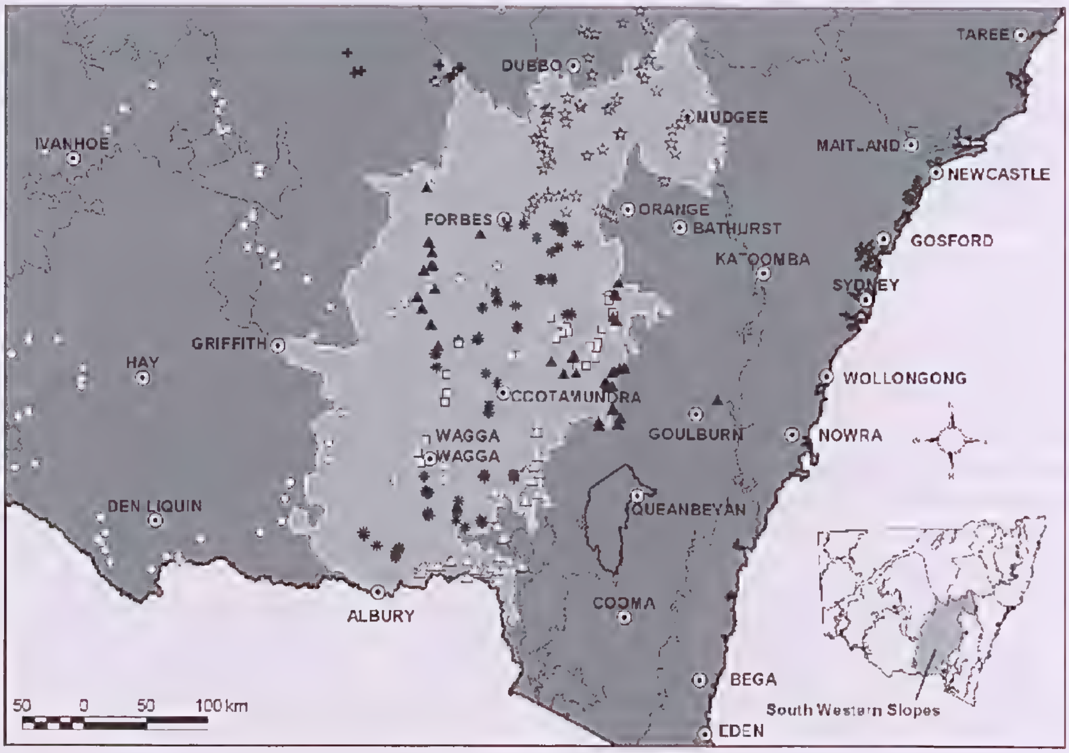

Fig. 6. Locations of field checks undertaken during six field trips between 2002 and 2007 that assisted in classifying the vegetation of the NSW South-western Slopes Bioregion.

bulk of the NSWSWS Bioregion, pre-European and current extent estimates for many plant communities were recorded with a low accuracy. Also, the sum of all pre-European extents for all the plant communities listed in the NSW South-western Slopes Bioregion is greater than the size of the bioregion (8.19 million hectares). This is because the NSWVCA records total extent over the full range of each plant community, not just its area in bioregion. Many NSWSWS plant communities extend into the South Eastern Highlands Bioregion in the east or into the NSW Western Plains Section of NSW to the west.

Plant community nomenclature

Historically, both internationally and in Australia, the naming of plant communities has been inconsistent when compared to the naming of species. No universal protocol for naming plant communities has been developed whereas species nomenclature follows the Latin binomial naming system devised in *Species Plantareum* by Carl Linneas in 1753. A plant community naming system was canvassed nearly 100 years ago at the 3rd International Botanical Conference in Brussels by Flahault & Schroter (1910). Subsequently, a hierarchical classification system of using scientific names of one to a few characteristic plant species was developed by the Zurich-Montpellier School (Braun-Blanquet 1932). This was modified for describing vegetation in Australia by Beadle & Costin (1952) – a system that remains influential today. Since then, numerous naming systems have been applied to vegetation classification and mapping. This deficiency in standardised nomenclature was discussed over 50 years ago by Moore (1953, page 498) in his seminal paper on the vegetation of the NSW south-western Slopes.

Subsequent to the plant community classification and nomenclature used in Beadle & Costin (1952), Carnaham (1990) produced standard names for the major structural vegetation types across Australia with reference to dominant plant genera. At finer levels of vegetation classification, nomenclature has varied widely. For example, regional ecosystems classified in Queensland are identified by a number followed by a description (Sattler & Williams 1999 and web updates). Alternatively, Victorian Ecological Vegetation Classes (see web link http://www.dse.vic.gov.au/DSE/nrence.nsf of the Victorian Department of Sustainability and Environment) contain short names that depict vegetation structure and landform (e.g. Low Rise Woodlands) mostly avoiding using English names of characteristic plant species.

Short structural / life–form nomenclature has also been applied in NSW regional vegetation surveys. For example, Keith & Bedward (1999) apply names such as “Lowland Swamp”, “Montane Heath” or “Foothills Dry Scrub Forest” to their map units covering the Eden region of south-eastern NSW. Tozer (2003) uses names such as “Shale Hills Woodland” and “Riparian Forest” in his map units for the Cumberland Plain in western Sydney. However, while these names are easy to use and recall, they are so generic that they could be applied to numerous ecological communities across Australia and throughout the world.

In order to overcome the nomenclature limitations highlighted above, the NSWVCA applies three types of names to each plant community:

A NSWVCA database ID number (e.g. ID285). This will change only if a community is deleted, split or amalgamated;

A “Scientific Name” containing up to 12 binomial Latin names of characteristic species in up to three vegetation layers;

A “Common Name” (in English) that conveys a colloquial description of the vegetation. The Name usually includes one or more dominant / diagnostic plant species, the most prevalent vegetation structural formation (based on Walker & Hopkins 1990), a reference to soil, substrate or climate and a reference to the main geographical occurrence in which a plant community occurs, such as a bioregion or a locality. Some plant communities may be described without a reference to species, e.g. “ID66 Artesian Mound Spring forbland/sedgeland mainly of the Mulga Lands Bioregion”. Although the “Common Name” may be more than 10 words long, it has the advantage of specifically describing a vegetation type for any region of Australia, thus avoiding confusion in provincial, national and international vegetation classifications.

The NSWVCA nomenclature is similar to that adopted for use in naming associations and alliances in the United States detailed in Jennings et al. (2006). The NSWVCA nomenclature was adopted for use in the NSW property vegetation planning scheme across New South Wales (Eco Logical Australia Pty Ltd 2006).

Table 1. List of 135 plant communities in the NSW South-western Slopes Bioregion by alphabetical order of formation group acronym showing their ID number; protected area/threat code; common name; pre-European, current and protected areas and ranges based on accuracy estimates; proportion in Catchment Management Authority areas (CMAs); and extent in protected areas with an accuracy code.

Notes: The formation group acronyms are correlated to formation group names in Table 4 in Benson (2006). The Protected Area/Threat code and the protected area extent accuracy codes M, E1-E4 are explained in Benson (2006). Folder 2 on the CD contains a full report (90 fields) and a short report (28 fields) listing all plant communities in the NSW South-western Slopes Bioregion. *indicates communities that occur in protected areas in the NSW Western Plains. # indicates communities that occur in protected areas in the NSW Tablelands or on the north-west slopes.

Formation Group Acronym	Veg ID: Threat/Protected Area Code Plant Community Common Name	ESTIMATED EXTENT: pre-European (range) Current Range (% pre-European) Protected Range (% pre-European)	% of Community in Bioregion	% of Community in CMA	Protected Area Name & Size (ha) (* = also on Western Slopes) (# = also on Tablelands or Northern Slopes)		Veg Area (ha) % Pre-European & Accuracy Code		
ASI	026: CE/5a Weeping Myall open woodland of the Riverina and NSW South-western Slopes Bioregions	1,600,000 (1,200,000 - 2,000,000) ha 120,000 - 200,000 ha (7.5 - 13 %) 740 - 890 ha (91 - 110 %)	<30% CP 30-70% NSS 30-70% RIV	<30% Central West <30% Lachlan <30% Murray 30-70% Murrumbidgee	Lake Urana NR* Oolambeyan NP* DE9905 PA*	302 21,839 663	10 715 88	<0.01 0.04 0.01	E3 M M
ASI	077: E/4a Yarran shrubland on peneplains and alluvial plains of central NSW	30,000 (15,000 - 45,000) ha 3,500 - 10,000 ha (12 - 33 %) 390 - 700 ha (72 - 130 %)	<30% BBS 30-70% CP <30% DRP <30% NSS	<30% Central West 30-70% Lachlan <30% Murray <30% Murrumbidgee <30% Western	Cocoparra NP* Cocoparra NR* Yathong NR*	8,364 4,775 108,768	1 42 500	<0.01 0.14 1.67	M M E2
ASI	317: LC/3b Currawang very tall shrubland on siliceous rocky ridges and cliffs mainly in the NSW South Western Slopes Bioregion	1,500 (1,400 - 1,600) ha 1,200 - 1,400 ha (80 - 93 %) 180 - 330 ha (70 - 130 %)	>70% NSS	<30% Central West <30% Lachlan <30% Murray <30% Murrumbidgee	Tabletop NR Livingstone NP Ulandra NR Dananbilla NR Nangar NP Weddin Mountains NP Benambra NP	102 1,918 3,958 2,436 9,356 8,697 1,400	31 25 89 20 30 20 42	2.07 1.67 5.93 1.33 2.00 1.33 2.80	M M M E4 E3 E3 E2
CCI	054: E/4a Buloke - White Cypress Pine woodland in the NSW South-western Slopes Bioregion	20,000 (10,000 - 30,000) ha 2,000 - 6,000 ha (10 - 30 %) 430 - 790 ha (70 - 130 %)	<30% DRP >70% NSS	<30% Central West 30-70% Lachlan	Goobang NP GE9902 PA# GE9903 PA#	42,347 8 935	600 8 4	3.00 0.04 0.02	M E2 E2

Formation Group Acronym	Veg ID: Threat/Protected Area Code Plant Community Common Name	ESTIMATED EXTENT: pre-European (range) Current Range (% pre-European) Protected Range (% pre-European)	% of Community in Bioregion	% of Community in CMA	Protected Area Name & Size (ha) (* = also on Western Slopes) (# = also on Tablelands or Northern Slopes)		Veg Area (ha) % Pre-European & Accuracy Code		
CCI	055: E/5a Belah woodland on alluvial plains in the central wheatbelt of NSW	450,000 (320,000 - 580,000) ha 49,000 - 91,000 ha (11 - 20 %) 380 - 690 ha (71 - 130 %)	<30% BBS <30% CP 30-70% DRP <30% NSS	<30% Border R/Gwydir <30% Central West <30% Namoi <30% Western <30% Lachlan	Boronga NR*	198	20	<0.01	E2
					Budelah NR*	4,049	1	<0.01	M
					Careunga NR#	492	395	0.09	M
					Kirramingly NR#	1,329	5	<0.01	E2
					Macquarie Marshes NR*	19,465	30	0.01	M
					Wilbertroy FR	136	6	<0.01	M
					Boomi NR*	157	20	<0.01	E2
					Boomi West NR*	148	15	<0.01	E2
					Brigalow Park NR#	251	15	<0.01	M
					VCA0008	400	25	0.01	M
CCI	057: NT/3a Belah/Black Oak - Western Rosewood - Wilga woodland of central NSW including the Cobar Peneplain Bioregion	350,000 (250,000 - 450,000) ha 140,000 - 260,000 ha (40 - 74 %) 14,000 - 25,000 ha (72 - 130 %)	30-70% CP 30-70% MDD <30% NSS	<30% Central West 30-70% Lachlan <30% Murrumbidgee <30% Western	Kajuligah NR*	13,833	6,000	1.71	E3
					Langtree NR*	232	200	0.06	M
					Mount Grenfell HS*	1,365	380	0.11	E3
					Nombinnie NR*	72,128	3,900	1.11	E1
					Nombinnie SCA*	53,258	1,000	0.29	E2
					Oolambeyan NP*	21,839	1	<0.01	M
					Round Hill NR*	13,642	251	0.07	M
					Scrubby Mountain FR*	1,704	500	0.14	E3
					Yathong NR*	108,768	7,200	2.06	E2
CCI	085: NT/4a River Oak forest and woodland of the NSW South-western Slopes and South Eastern Highlands Bioregions	30,000 (15,000 - 45,000) ha 4,000 - 12,000 ha (13 - 40 %) 850 - 1,500 ha (71 - 120 %)	>70% NSS <30% SEH	30-70% Lachlan 30-70% Murrumbidgee <30% ACT	Abercrombie River NP#	18,845	205	0.68	M
					Barton NR#	533	3	0.01	M
					Brindabella NP#	18,141	220	0.73	M
					Copperhannia NR#	3,507	25	0.08	M
					Evans Crown NR#	432	5	0.02	E1
					Girralang NR#	652	50	0.17	E2
					Mullion Range SCA#	1,047	100	0.33	E2
					Narrandera NR	59	1	<0.01	E1
					Tarlo River NP#	8,179	200	0.67	E2
					Turon NP#	3,053	350	1.17	E2
					Wee Jasper NR#	629	4	0.01	M
					Oak Creek NR#	403	5	0.02	E1
					Black Andrew NR#	1,557	37	0.12	E1

Formation Group Acronym	Veg ID: Threat/Protected Area Code Plant Community Common Name	ESTIMATED EXTENT: pre-European (range) Current Range (% pre-European) Protected Range (% pre-European)	% of Community in Bioregion	% of Community in CMA	Protected Area Name & Size (ha) (* = also on Western Slopes) (# = also on Tablelands or Northern Slopes)		Veg Area (ha) % Pre-European & Accuracy Code		
CPW	048: CE/5b White Cypress Pine-Drooping Sheoak grassy open woodland of the Riverine Plain	5,000 (2,500 - 7,500) ha 250 - 750 ha (5 - 15 %) 0 ha	<30% NSS >70% RIV	30-70% Murray <30% Murrumbidgee	Not Protected				
CPW	070: V/5a White Cypress Pine woodland of central NSW	200,000 (100,000 - 300,000) ha 35,000 - 100,000 ha (18 - 50 %) 28 - 52 ha (70 - 130 %)	<30% BBS <30% CP <30% DRP <30% MDD 30-70% NSS	<30% Border R/Gwydir 30-70% Central West 30-70% Lachlan <30% Namoi	Strahorn FR*	72	40	0.02	E2
CPW	309: LC/1a Black Cypress Pine - Red Stringybark - red gum - box low open forest on siliceous rocky outcrops in the NSW South-western Slopes Bioregion	20,000 (14,000 - 26,000) ha 12,000 - 22,000 ha (60 - 110 %) 5,800 - 10,000 ha (70 - 120 %)	30-70% NSS <30% SEH	<30% Murray 30-70% Murrumbidgee <30% Lachlan	Bogandyera NR#	9,463	123	0.62	E1
					Minjary NP	1,459	358	1.79	E1
					Mudjarn NR	590	332	1.66	M
					Ulandra NR	3,958	270	1.35	E4
					Winburndale NR#	11,047	29	0.15	M
					Conimbla NP	7,948	3,340	16.7	E1
					Dananbilla NR	2,436	100	0.50	E3
					Livingstone NP	1,918	80	0.40	E3
					Woomargama NP	24,185	3,600	18.0	E2
EBWP	056: V/5a Poplar Box - Belah woodland on clay-loam soils of the alluvial plains of north-central NSW	450,000 (180,000 - 720,000) ha 70,000 - 130,000 ha (16 - 29 %) 160 - 290 ha (71 - 130 %)	30-70% BBS <30% CP 30-70% DRP <30% NSS	30-70% Border R/Gwydir 30-70% Central West <30% Lachlan <30% Namoi <30% Western	Boronga NR*	198	10	<0.01	E3
					Macquarie Marshes NR*	19,465	200	0.04	M
					Boomi NR*	157	5	<0.01	E3
					Boomi West NR*	148	10	<0.01	E2
EBWP	075: E/5a Yellow Box - White Cypress Pine grassy woodland on deep sandy-loam alluvial soils of the eastern Riverina and western NSW South-western Slopes Bioregions	100,000 (50,000 - 150,000) ha 5,600 - 10,000 ha (5.6 - 10 %) 250 - 460 ha (70 - 130 %)	30-70% NSS 30-70% RIV	30-70% Murray 30-70% Murrumbidgee	Lake Urana NR*	302	271	0.27	M
					Wilbertroy FR	136	86	0.09	E1
					VCA0117	3	3	<0.01	E1

Formation Group Acronym	Veg ID: Threat/Protected Area Code Plant Community Common Name	ESTIMATED EXTENT: pre-European (range) Current Range (% pre-European) Protected Range (% pre-European)	% of Community in Bioregion	% of Community in CMA	Protected Area Name & Size (ha) (* = also on Western Slopes) (# = also on Tablelands or Northern Slopes)		Veg Area (ha) % Pre-European & Accuracy Code		
EBWP	076: CE/5a Inland Grey Box tall grassy woodland on alluvial loam and clay soils in the NSW South Western Slopes and Riverina Bioregions	500,000 (350,000 - 650,000) ha 28,000 - 52,000 ha (5.6 - 10 %) 150 - 270 ha (71 - 130 %)	30-70% NSS <30% RIV	<30% Lachlan <30% Murray <30% Murrumbidgee	Flagstaff Memorial NR Wiesners Swamp NR AL9913 PA HE9901 PA NA9904 PA VCA0108 WW0001 PA#	18 102 16 8 43 4 155	10 20 8 33 38 4 97	<0.01 <0.01 <0.01 0.01 0.01 <0.01 0.02	E2 E1 E1 E2 E2 M E2
EBWP	080: E/5a Inland Grey Box - White Cypress Pine tall woodland on loam soil on alluvial plains of NSW South-western Slopes and Riverina Bioregions	800,000 (560,000 - 1,000,000) ha 98,000 - 180,000 ha (12 - 23 %) 280 - 510 ha (71 - 130 %)	<30% NSS 30-70% RIV	<30% Lachlan <30% Murray <30% Murrumbidgee	Buckingbong FR Gubbata NR* Wilbertroy FR AL9907 PA AL9908 PA AL9909 PA AL9910 PA AL9921 PA	163 151 136 19 125 125 125 125	155 5 22 14 17 30 134 19	0.02 <0.01 <0.01 <0.01 <0.01 <0.01 0.02 <0.01	M E1 E1 E1 E1 M M E1
EBWP	082: E/5a Inland Grey Box - Poplar Box - White Cypress Pine tall woodland on red loams mainly of the eastern Cobar Peneplain Bioregion	400,000 (280,000 - 520,000) ha 70,000 - 130,000 ha (18 - 33 %) 320 - 380 ha (92 - 110 %)	30-70% CP <30% MDD <30% NSS	30-70% Central West 30-70% Lachlan <30% Western <30% Murrumbidgee	Cocoparra NP* Cocoparra NR* Strahorn FR* Woggoon NR* CD9910 PA WE9902 PA#	8,364 4,775 72 6,113 36 519	3 64 30 200 36 15	<0.01 0.02 0.01 0.05 0.01 <0.01	E1 E1 E3 E1 E1 E1
EBWP	083: E/5a Yellow Box woodland on sandy loam soils on alluvial plains mainly in the upper Darling Riverine Plain Bioregion	30,000 (15,000 - 45,000) ha 3,000 - 9,000 ha (10 - 30 %) 0 ha	>70% DRP <30% NSS	30-70% Central West <30% Namoi	Not Protected				
EBWP	110: V/5a Inland Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes and Riverina Bioregions	40,000 (20,000 - 60,000) ha 5,000 - 15,000 ha (13 - 38 %) 210 - 370 ha (73 - 130 %)	<30% CP >70% NSS	<30% Lachlan <30% Murray <30% Murrumbidgee	Cocoparra NP* Cocoparra NR* Nangar NP The Rock NR	8,364 4,775 9,356 343	100 41 17 130	0.25 0.10 0.04 0.33	M M M E2
EBWP	201: CE/5a Fuzzy Box - Inland Grey Box on alluvial brown loam soils mainly in the NSW South-western Slopes Bioregion	100,000 (70,000 - 130,000) ha 4,200 - 7,800 ha (4.2 - 7.8 %) 56 - 100 ha (70 - 130 %)	<30% BBS <30% CP >70% NSS	<30% Central West 30-70% Lachlan	Coolbaggie NR# Weddin Mountains NP VCA0008	1,773 8,697 400	50 27 3	0.05 0.03 <0.01	E2 M E4

Formation Group Acronym	Veg ID: Threat/Protected Area Code Plant Community Common Name	ESTIMATED EXTENT: pre-European (range) Current Range (% pre-European) Protected Range (% pre-European)	% of Community in Bioregion	% of Community in CMA	Protected Area Name & Size (ha) (* = also on Western Slopes) (# = also on Tablelands or Northern Slopes)		Veg Area (ha) % Pre-European & Accuracy Code		
EBWP	244: E/5a Poplar Box grassy/shrubby woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt).	1,500,000 (1,100,000 - 1,900,000) ha 280,000 - 520,000 ha (19 - 35 %) 170 - 500 ha (51 - 150 %)	<30% BBS 30-70% DRP <30% NSS	30-70% Border R/Gwydir <30% Central West <30% Lachlan <30% Namoi <30% Western	Boomi NR* Boomi West NR* Budelah NR* Midkin NR* Boronga NR* NY9902 PA	157 148 4,049 374 198 20	30 54 22 190 20 20	<0.01 <0.01 <0.01 0.01 <0.01 <0.01	E2 E2 M M E3 M
EBWP	248: E/5a Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW	50,000 (25,000 - 75,000) ha 5,000 - 15,000 ha (10 - 30 %) 0 ha	30-70% CP 30-70% NSS	<30% Central West 30-70% Lachlan	Not Protected				
EBWP	258: NT/5a Gum Coolabah - Mugga ironbark - White Cypress Pine woodland on granite low hills in the eastern Cobar Peneplain Bioregion and central NSW SWS Bioregion	32,000 (23,000 - 41,000) ha 14,000 - 26,000 ha (44 - 81 %) 4 - 7 ha (70 - 130 %)	30-70% CP <30% NSS	>70% Central West <30% Western	Snake Rock AA	61	5	0.02	E2
EBWT	266: CE/5a White Box grassy woodland in the upper slopes sub-region of the NSW South-western Slopes Bioregion	800,000 (560,000 - 1,000,000) ha 35,000 - 65,000 ha (4.4 - 8.1 %) 230 - 420 ha (71 - 130 %)	>70% NSS <30% SEH	<30% Central West <30% Lachlan <30% Murray <30% Murrumbidgee	Flagstaff Memorial NR Barton NR# Minjary NP Tumblong SCA Oak Creek NR# VCA0116 VCA0111 HE9901 PA WT9908 PA	18 533 1,459 745 403 4 3 8 230	6 6 30 106 100 4 3 6 64	<0.01 <0.01 <0.01 0.01 0.01 <0.01 <0.01 <0.01 0.01	E2 M E3 E1 E3 M E1 E2 E2
EBWT	267: E/5a White Box - White Cypress Pine - Inland Grey Box shrub/grass/forb woodland in the NSW South-western Slopes Bioregion	70,000 (35,000 - 100,000) ha 4,000 - 12,000 ha (5.7 - 17 %) 12 - 14 ha (92 - 110 %)	>70% NSS	<30% Central West <30% Lachlan <30% Murray <30% Murrumbidgee	Wiesners Swamp NR VCA0038	102 2	10 3	0.01 <0.01	E1 M

Formation Group Acronym	Veg ID: Threat/Protected Area Code Plant Community Common Name	ESTIMATED EXTENT: pre-European (range) Current Range (% pre-European) Protected Range (% pre-European)	% of Community in Bioregion	% of Community in CMA	Protected Area Name & Size (ha) (* = also on Western Slopes) (# = also on Tablelands or Northern Slopes)		Veg Area (ha) % Pre-European & Accuracy Code		
EBWT	268: V/4a White Box - Blakelys Red Gum - Long-leaved Box - Nortons Box - Red Stringybark grass-shrub woodland on shallow soils on hills in the New South Wales South-western Slopes Bioregion	80,000 (56,000 - 100,000) ha 21,000 - 39,000 ha (26 - 49 %) 1,100 - 1,900 ha (75 - 130 %)	>70% NSS	30-70% Murray 30-70% Murrumbidgee <30% Central West <30% Lachlan	Benambra NP Livingstone NP Livingstone SCA Nest Hill NR Tabletop NR Woomargama NP Tarcutta Hills BHR	,400 1,918 582 758 102 24,185 432	1,029 230 28 60 7 30 80	1.29 0.29 0.04 0.08 0.01 0.04 0.10	M E1 M M M E3 E2
EBWT	269: E/5b White Box - Blakelys Red Gum - Red Box - Red Stringybark shrubby woodland on shallow soils on metamorphic hills in the Albury region of the NSW South-western Slopes Bioregion	4,500 (4,100 - 4,900) ha 900 - 1,100 ha (20 - 24 %) 0 ha	>70% NSS	>70% Murray	Not Protected				
EBWT	270: NT/5a White Box - Tumbledown Gum - Long-leaved Box shrub/grass woodland on fine-grained sediments of the upper Macquarie River gorge, NSW central western slopes	10,000 (5,000 - 15,000) ha 4,200 - 7,800 ha (42 - 78 %) 0 ha	30-70% SEH 30-70% NSS	>70% Central West	Not Protected				
EBWT	272: V/3a White Box - Black Cypress Pine - red gum +/- Mugga Ironbark shrubby woodland in hills of the NSW central western slopes	20,000 (10,000 - 30,000) ha 3,500 - 10,000 ha (18 - 50 %) 1,500 - 1,800 ha (91 - 110 %)	>70% NSS	30-70% Central West 30-70% Lachlan	Nangar NP Barton NR# Goobang NP Boginderra Hills NR Weddin Mountains NP Eugowra NR Dananbilla NR Koorawatha NR Gungewalla NR Illunie NR	9,356 533 42,347 798 8,697 115 2,436 1,111 140 732	301 2 310 15 238 16 400 265 10 90	1.51 0.01 1.55 0.08 1.19 0.08 2.00 1.33 0.05 0.45	M M E1 M M E2 E1 E1 E3 E2
EBWT	273: V/4a White Box shrubby open forest on fine grained sediments on steep slopes in the Mudgee region of the of central western slopes of NSW	30,000 (15,000 - 45,000) ha 6,000 - 18,000 ha (20 - 60 %) 280 - 520 ha (70 - 130 %)	>70% NSS	>70% Central West	Avisford NR	2,587	400	1.33	E2

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EBWT	274: E/5b White Box - Rough-barked Apple alluvial woodland of the NSW central western slopes including in the Mudgee region	8,000 (5,600 - 10,000) ha 900 - 1,100 ha (11 - 14 %) 140 - 260 ha (70 - 130 %)	>70% NSS	>70% Central West	Avisford NR	2,587	200	2.50	E2
EBWT	275: E/5b Herbaceous White Box - Apple Box valley woodland of the NSW central western slopes	6,000 (3,000 - 9,000) ha 500 - 1,500 ha (8.3 - 25 %) 32 - 58 ha (71 - 130 %)	30-70% NSS 30-70% SEH	30-70% Central West <30% Lachlan	Barton NR#	533	45	0.75	M
EBWT	276: CE/5a Yellow Box grassy tall woodland on alluvium or parna loams and clays on flats in NSW South-western Slopes Bioregion	40,000 (20,000 - 60,000) ha 2,000 - 6,000 ha (5 - 15 %) 52 - 94 ha (71 - 130 %)	>70% NSS	<30% Central West <30% Lachlan <30% Murrumbidgee	YO0102 PA WT9910 PA	43 230	43 30	0.11 0.08	E2 E2
EBWT	277: CE/5a Blakelys Red Gum - Yellow Box grassy tall woodland of the NSW South-western Slopes Bioregion	500,000 (350,000 - 650,000) ha 21,000 - 39,000 ha (4.2 - 7.8 %) 1,100 - 1,800 ha (77 - 130 %)	<30% SEH >70% NSS	<30% Central West <30% Lachlan <30% Murray <30% Murrumbidgee	Boginderra Hills NR Ulandra NR Woomargama NP Jingellic NR Conimbla NP WW9901 PA# WT9902 PA	798 3,958 24,185 2,140 7,948 18 230	10 758 220 24 90 17 313	<0.01 0.15 0.04 <0.01 0.02 <0.01 0.06	M E1 E1 M E4 E2 E2
EBWT	278: E/3a Riparian Blakelys Red Gum - box - shrub - sedge - grass tall open forest of the central NSW South-western Slopes Bioregion	30,000 (15,000 - 45,000) ha 3,000 - 9,000 ha (10 - 30 %) 1,700 - 5,000 ha (50 - 150 %)	30-70% NSS 30-70% SEH	<30% Central West <30% Lachlan <30% Murrumbidgee	Conimbla NP Goobang NP VCA0081	7,948 42,347 224	353 3,000 21	1.18 10.0 0.07	M E1 E3
EBWT	279: V/4a Blakelys Red Gum - White Cypress Pine woodland on footslopes of hills in central part of the NSW South-western Slopes Bioregion	12,000 (6,000 - 18,000) ha 2,000 - 6,000 ha (17 - 50 %) 480 - 880 ha (70 - 130 %)	>70% NSS	30-70% Lachlan 30-70% Central West	Nangar NP Weddin Mountains NP	9,356 8,697	261 423	2.18 3.53	M M

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EBWT	280: E/4a Blakelys Red Gum - Long-leaved Box - Red Stringybark shrub/grass hill woodland of the NSW South-western Slopes Bioregion	60,000 (30,000 - 90,000) ha 6,000 - 18,000 ha (10 - 30 %) 630 - 1,100 ha (70 - 120 %)	>70% NSS	30-70% Lachlan 30-70% Murrumbidgee <30% Central West	Ulandra NR	3,958	900	1.50	E3
EBWT	281: CE/5a Rough-Barked Apple - Yellow Box - Blakelys Red Gum woodland on valley flats in the NSW western Slopes	25,000 (13,000 - 37,000) ha 1,000 - 3,000 ha (4 - 12 %) 50 - 150 ha (50 - 150 %)	30-70% BBS <30% NAN <30% NSS <30% SB	<30% Central West <30% Namoi <30% Hunter/Central R	Coolbaggie NR#	1,773	100	0.40	E2
EBWT	282: E/4a Blakelys Red Gum - White Box - Yellow Box - Black Cypress Pine box grass/shrub woodland on clay loam soils on undulating hills of central NSW South-western Slopes Bioregion	70,000 (35,000 - 100,000) ha 2,500 - 7,500 ha (3.6 - 11 %) 550 - 1,000 ha (71 - 130 %)	30-70% NSS <30% SEH	<30% Central West <30% Lachlan <30% Murray <30% Murrumbidgee	Mudjarn NR	590	24	0.03	E1
					Ulandra NR	3,958	105	0.15	E1
					Minjary NP	1,459	103	0.15	M
					Dananbilla NR	2,436	330	0.47	E1
					Illunie NR	732	110	0.16	E1
					Koorawatha NR	1,111	12	0.02	M
					Gungewalla NR	140	40	0.06	E1
					VCA0036	4	4	0.01	E1
					VCA0037	53	50	0.07	E3
EBWT	283: CE/5a Apple Box - Blakelys Red Gum moist valley and footslopes grass-forb open forest of the NSW South-western Slopes Bioregions	35,000 (18,000 - 52,000) ha 2,100 - 3,900 ha (6 - 11 %) 76 - 220 ha (50 - 150 %)	30-70% NSS <30% SEH	<30% ACT <30% Central West <30% Lachlan <30% Murray <30% Murrumbidgee	Ellerslie NR	1,879	120	0.34	E1
					Woomargama NP	24,185	11	0.03	E1
					Bogandyera NR#	9,463	10	0.03	E4
					Livingstone NP	1,918	10	0.03	E3
EBWT	284: V/5b Red Stringybark - Blakelys Red Gum - tea tree herbaceous swampy valley open forest of the Murraguldrie region in the southern NSW South-western Slopes Bioregion	3,000 (2,100 - 3,900) ha 700 - 1,300 ha (23 - 43 %) 110 - 130 ha (92 - 110 %)	>70% NSS	>70% Murrumbidgee <30% Murray	Murraguldrie FR	1,520	120	4.00	E1
EBWT	286: E/4b Red Box - Blakelys Red Gum sedge woodland on colluvial clay drainage lines in the NSW South-western Slopes Bioregion	2,000 (1,400 - 2,600) ha 280 - 520 ha (14 - 26 %) 93 - 110 ha (90 - 110 %)	>70% NSS	>70% Murray	Benambra NP	1,400	103	5.15	M

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EBWT	287: V/4a Long-leaved Box - Red Box - Red Stringybark mixed open forest on hills and hillslopes in the NSW South-western Slopes Bioregion	60,000 (30,000 - 90,000) ha 10,000 - 30,000 ha (17 - 50 %) 2,000 - 3,500 ha (72 - 130 %)	>70% NSS <30% SEH	<30% Murray 30-70% Murrumbidgee <30% Lachlan <30% Central West	Murraguldrie FR	1,520	1,280	2.13	E2
					Tumblong SCA	745	8	0.01	E1
					Ellerslie NR	1,879	600	1.00	E2
					Benambra NP	1,400	114	0.19	E1
					Minjary NP	1,459	42	0.07	E1
					Mudjarn NR	590	197	0.33	E1
					Barton NR#	533	122	0.20	E1
					Nangar NP	9,356	200	0.33	E2
					Conimbla NP	7,948	200	0.33	E3
EBWT	293: LC/4c Nortons Box shrubby low woodland on sandstone and conglomerate escarpments in the far southern part of the NSW South Western Slopes	400 (280 - 520) ha 350 - 410 ha (88 - 100 %) 55 - 67 ha (90 - 110 %)	>70% NSS	>70% Murray	Benambra NP	1,400	21	5.25	M
					Tabletop NR	102	40	10.0	E1
EBWT	294: NT/2a Nortons Box - Red Box - White Box tussock grass open forest of the southern section of the NSW South-western Slopes Bioregion	15,000 (11,000 - 19,000) ha 5,600 - 10,000 ha (37 - 67 %) 2,000 - 3,600 ha (71 - 130 %)	>70% NSS <30% SEH	30-70% Murray 30-70% Murrumbidgee	Tumblong SCA	745	344	2.29	E1
					Woomargama NP	24,185	950	6.33	E1
					Mullengandra NR	150	70	0.47	E3
					Woomargama SCA	7,046	1,450	9.67	E1
EBWT	298: E/5b Apple Box - Nortons Box - Blakelys Red Gum valley flat moist grassy tall open forest in the southern NSW South-western Slopes and adjoining South East Highlands Bioregions	5,000 (2,500 - 7,500) ha 350 - 1,000 ha (7 - 20 %) 150 - 270 ha (70 - 130 %)	30-70% SEH 30-70% NSS	30-70% Murrumbidgee 30-70% Murray	Bogandyera NR#	9,463	30	0.60	E1
					Jingellic NR	2,140	30	0.60	M
					Wereboldera SCA	2,255	11	0.22	M
					Downfall NR	483	12	0.24	M
					Woomargama NP	24,185	100	2.00	E2
					Woomargama SCA	7,046	30	0.60	E1
EBWT	304: CE/4a Candlebark - Apple Box - Robertson's Peppermint tall open forest on granite in the Tumbarumba region of the South East Highlands and upper NSW South-western Slopes Bioregions	10,000 (7,000 - 13,000) ha 700 - 1,300 ha (7 - 13 %) 250 - 460 ha (70 - 130 %)	30-70% NSS 30-70% SEH	>70% Murray	Bogandyera NR#	9,463	66	0.66	M
					Clarkes Hill NR#	2,206	291	2.91	M

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EBWT	305: NT/2a Apple Box - Broad-leaved Peppermint - Red Stringybark shrubby hill open forest in the upper NSW South-western Slopes Bioregion and adjacent South Eastern Highlands Bioregion	10,000 (5,000 - 15,000) ha 3,000 - 9,000 ha (30 - 90 %) 1,900 - 3,400 ha (71 - 130 %)	30-70% SEH <30% NSS	30-70% Murray 30-70% Murrumbidgee	Bogandyera NR# Clarkes Hill NR# Downfall NR Courabyra NR# Carabost FR# Mundaroo FR#	9,463 2,206 483 240 2,803 1,946	60 1,642 42 39 400 500	0.60 16.4 0.42 0.39 4.00 5.00	E1 E1 E1 E3 E4 E4
EBWT	312: CE/5a Yellow Box grassy tall woodland on valley flats in the upper slopes of the South-western Slopes Bioregion and South Eastern Highlands Bioregion	40,000 (28,000 - 52,000) ha 2,100 - 3,900 ha (5.3 - 9.8 %) 110 - 190 ha (75 - 130 %)	30-70% NSS 30-70% SEH	30-70% Murrumbidgee 30-70% Murray	Bogandyera NR# Woomargama NP	9,463 24,185	97 50	0.24 0.13	M E4
EBWT	314: V/4c Apple Box - Red Stringybark basalt scree open forest in the upper Murray River region	40 (28 - 52) ha 18 - 22 ha (45 - 55 %) 6 - 8 ha (90 - 110 %)	>70% NSS	>70% Murray	Bogandyera NR#	9,463	7	17.5	M
EBWT	315: LC/4c Red Box - Dwyers Red Gum low woodland on shallow red earths on upper hillslopes and hillcrests in the upper Murray River region	400 (360 - 440) ha 270 - 330 ha (68 - 83 %) 49 - 91 ha (70 - 130 %)	>70% NSS	>70% Murray	Jingellic NR	2,140	70	17.5	E1
EBWT	316: V/4b Nortons Box - Red Box - Red Stringybark - Nodding Flax Lily forb-grass open forest - woodland mainly on the Minjary Range north of Tumut	8,000 (5,600 - 10,000) ha 2,100 - 3,900 ha (26 - 49 %) 530 - 970 ha (71 - 130 %)	>70% NSS	>70% Murrumbidgee	Minjary NP	1,459	750	9.38	E2
EBWT	326: V/5b Long-leaved Box - Red Box grass-shrub open forest on hillslopes in the Mudgee Region, NSW central western slopes	8,000 (4,000 - 12,000) ha 1,500 - 4,500 ha (19 - 56 %) 91 - 160 ha (70 - 120 %)	>70% NSS	>70% Central West	Avisford NR	2,587	130	1.63	E2

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EBWT	341: E/4a Blakelys Red Gum - Red Box - Black Cypress Pine grass/shrub woodland on hills in the upper slopes sub-region of the NSW South-western Slopes and western South Eastern Highlands Bioregions	7,000 (4,900 - 9,100) ha 1,100 - 1,900 ha (16 - 27 %) 260 - 260 ha (100 - 100 %)	30-70% NSS 30-70% SEH	30-70% Lachlan 30-70% Murrumbidgee	Illunie NR VCA0033	732 155	210 50	3.00 0.71	E1 E3
EBWT	347: V/3a White Box - Blakelys Red Gum shrub/grass woodland on metamorphic hillslopes in the mid-southern part of the upper slopes sub-region of the NSW South-western Slopes Bioregion	12,000 (6,000 - 18,000) ha 2,300 - 6,700 ha (19 - 56 %) 660 - 1,200 ha (71 - 130 %)	>70% NSS	30-70% Murrumbidgee <30% Lachlan	Ellerslie NR Tarcutta Hills BHR	1,879 432	800 130	6.67 1.08	E2 E2
EBWT	350: E/5b Candlebark - Blakelys Red Gum - Long-leaved Box grassy woodland in the Rye Park to Yass region of the NSW South-western Slopes and South-Eastern Highland Bioregions	15,000 (11,000 - 19,000) ha 1,400 - 2,600 ha (9.3 - 17 %) 0 ha	>70% SEH <30% NSS	<30% Murrumbidgee >70% Lachlan	Not Protected				
EBWT	352: E/5a Red Stringybark - Blakelys Red Gum hillslope open forest on meta-sediments in the Yass - Boorowa - Crookwell region of the NSW South-western Slopes and South Eastern Highlands Bioregions	50,000 (35,000 - 65,000) ha 4,900 - 9,100 ha (9.8 - 18 %) 0 ha	30-70% NSS 30-70% SEH	30-70% Lachlan <30% Murrumbidgee	Not Protected				
ECT	295: LC/1a Robertson's Peppermint - Broad-leaved Peppermint - Nortons Box - stringybark shrub-fern open forest of the NSW South Western Slopes and SHE Bioregions	30,000 (15,000 - 45,000) ha 9,000 - 27,000 ha (30 - 90 %) 11,000 - 20,000 ha (71 - 130 %)	>70% NSS <30% SEH	30-70% Murray <30% Murrumbidgee	Woomargama NP Wereboldera SCA Bogandyera NR# Courabyra NR# Kosciuszko NP# Carabost FR# Woomargama SCA Mundaroo FR#	24,185 2,255 9,463 240 689,464 2,803 7,046 1,946	6,240 118 892 50 5,000 900 1,720 500	20.8 0.39 2.97 0.17 16.7 3.00 5.73 1.67	E2 E1 M E3 E3 E4 E1 E4

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ECT	299: NT/4b Riparian Ribbon Gum - Robertsons Peppermint - Apple Box riverine very tall open forest of the NSW South Western Slopes and South East Highlands Bioregions	8,000 (5,600 - 10,000) ha 2,800 - 5,200 ha (35 - 65 %) 370 - 1,100 ha (50 - 150 %)	30-70% NSS 30-70% SEH	>70% Murray <30% Murrumbidgee	Clarkes Hill NR#	2,206	30	0.38	M
					Bogandyera NR#	9,463	195	2.44	M
					Jingellic NR	2,140	2	0.03	M
					Wereboldera SCA	2,255	10	0.13	E3
					Kosciuszko NP#	689,464	500	6.25	E3
ECT	300: LC/1a Ribbon Gum - Robertson Peppermint montane fern - grass tall open forest on deep clay loam soils in the upper NSW SWS Bioregion and western Kosciuszko escarpment	100,000 (70,000 - 130,000) ha 56,000 - 100,000 ha (56 - 100 %) 49,000 - 90,000 ha (71 - 130 %)	>70% SEH <30% NSS <30% AA	30-70% Murray 30-70% Murrumbidgee	Bogandyera NR#	9,463	148	0.15	E1
					Jingellic NR	2,140	100	0.10	E1
					Kosciuszko NP#	689,464	69,000	69.0	E2
ECT	307: NT/4b Eurabbie - Robertson's Peppermint very tall, fern open forest of gullies and sheltered hillslopes in the southern most part of the NSW South-western Slopes Bioregion	4,000 (3,600 - 4,400) ha 2,700 - 3,300 ha (68 - 83 %) 230 - 680 ha (51 - 150 %)	30-70% SEH 30-70% NSS	>70% Murray <30% Murrumbidgee	Woomargama NP	24,185	350	8.75	E3
					Bago FR#	23	55	1.38	E1
					Mundaroo FR#	1,946	50	1.25	E3
EIW	002: NT/3a River Red Gum-sedge dominated very tall open forest in frequently flooded sites along major rivers and floodplains in south-western NSW	35,000 (25,000 - 45,000) ha 21,000 - 39,000 ha (60 - 110 %) 2,300 - 4,200 ha (70 - 130 %)	<30% NSS >70% RIV	>70% Murray <30% Murrumbidgee <30% Lachlan	Billabong FR*	309	50	0.14	E3
					Moira Lakes FR*	1,418	40	0.11	E3
					Native Dog FR*	3	43	0.12	E3
					Pollack FR*	714	100	0.29	E3
					Sanddune Pine FR*	60	10	0.03	E3
					Snake Island FR*	36	5	0.01	E3
					Toupna Creek FR*	79	2	0.01	E3
					Yanga NP*	36,438	3,000	8.57	E3
					Yanga SCA*	33,777	30	0.09	E4
EIW	005: NT/4a River Red Gum herbaceous-grassy very tall open forest on inner floodplains in the lower slopes sub-region of the NSW South West Slopes Bioregion and the eastern Riverina Bioregion	15,000 (7,500 - 22,000) ha 4,500 - 13,000 ha (30 - 87 %) 200 - 360 ha (71 - 130 %)	30-70% NSS 30-70% RIV	>70% Murray <30% Murrumbidgee <30% Lachlan	Billabong FR*	309	110	0.73	E3
					Moira Lakes FR*	1,418	50	0.33	E3
					Narrandera FR*	14	12	0.08	E1
					Narrandera NR	59	50	0.33	E2
					Snake Island FR*	36	30	0.20	E3
					Toupna Creek FR*	79	10	0.07	E3
					Wilbertroy FR	136	20	0.13	E3

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EIW	009: V/3a River Red Gum - wallaby grass tall woodland on the outer River Red Gum zone mainly in the Riverina Bioregion	35,000 (25,000 - 45,000) ha 8,400 - 15,000 ha (24 - 43 %) 1,600 - 2,800 ha (73 - 130 %)	<30% NSS >70% RIV	>70% Murray <30% Murrumbidgee <30% Lachlan	Billabong FR* Moira Lakes FR* Yanga NP* Yanga SCA*	309 1,418 36,438 33,777	117 30 2,000 30	0.33 0.09 5.71 0.09	E3 E3 E3 E4
EIW	074: E/5a Yellow Box - River Red Gum tall grassy riverine woodland of NSW South West Slopes and Riverina Bioregions	30,000 (21,000 - 39,000) ha 5,600 - 10,000 ha (19 - 33 %) 19 - 35 ha (70 - 130 %)	30-70% NSS 30-70% RIV	<30% Lachlan <30% Murray <30% Murrumbidgee	Narrandera NR Sanddune Pine FR* Toupna Creek FR* DE9906 PA	59 60 79 43	8 3 13 3	0.03 0.01 0.04 0.01	E2 E3 E3 M
EIW	079: V/5a River Red Gum shrub/grass riparian tall woodland or open forest mainly in the upper slopes sub-region of the NSW South Western Slopes bioregion and western South East Highlands Bioregion	35,000 (18,000 - 52,000) ha 6,000 - 18,000 ha (17 - 51 %) 25 - 45 ha (71 - 130 %)	>70% NSS <30% SEH	<30% Lachlan 30-70% Murray 30-70% Murrumbidgee	Hattons Corner NR# Koorawatha NR Flagstaff Memorial NR GE9907 PA# VCA0008 VCA0084	4 1,111 18 62 400 14	1 5 2 10 7 10	<0.01 0.01 0.01 0.03 0.02 0.03	E1 E1 E2 E1 E4 E2
EIW	237: E/5a Riverine Inland Grey Box grassy woodland of the semi-arid (warm) climate zone	15,000 (7,500 - 22,000) ha 2,800 - 5,200 ha (19 - 35 %) 9 - 27 ha (50 - 150 %)	30-70% NSS 30-70% RIV	<30% Lachlan 30-70% Murray <30% Murrumbidgee	Billabong FR* Sanddune Pine FR* Toupna Creek FR*	309 60 79	2 3 13	0.01 0.02 0.09	E3 E3 E3
EIW	249: V/5b River Red Gum grass - swamp woodland to open woodland on cowals (lakes) and associated flood channels in central NSW	6,500 (3,300 - 9,700) ha 1,500 - 4,500 ha (23 - 69 %) 56 - 100 ha (71 - 130 %)	<30% DRP 30-70% NSS <30% RIV	30-70% Central West <30% Lachlan <30% Murrumbidgee <30% Murray	Lake Urana NR* Wiesners Swamp NR	302 102	9 70	0.14 1.08	M E1
EIW	251: E/5a Mixed Eucalypt woodlands of floodplains in the southern-eastern Cobar Peneplain Bioregion	35,000 (18,000 - 52,000) ha 5,000 - 15,000 ha (14 - 43 %) 62 - 110 ha (70 - 130 %)	30-70% CP 30-70% NSS	>70% Lachlan	CD9901 PA	229	88	0.25	E2
EIW	356: V/5c Blakelys Red Gum x Dirty Gum - White Cypress Pine tall woodland lining sandy watercourses in the NSW South-western Slopes Bioregion	1,000 (700 - 1,300) ha 280 - 520 ha (28 - 52 %) 0 ha	>70% NSS	30-70% Lachlan 30-70% Central West	Not Protected				

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EIWI	217: V/3a Mugga Ironbark - Inland Grey Box - cypress pine tall woodland on footslopes of low hills in the NSW South-western Slopes Bioregion	80,000 (40,000 - 120,000) ha 13,000 - 37,000 ha (16 - 46 %) 4,400 - 5,300 ha (91 - 110 %)	>70% NSS <30% RIV	<30% Central West 30-70% Lachlan <30% Murrumbidgee	Big Bush NR Blue Mallee FR Buddigower NR Ingalba NR Pucawan NR The Charcoal Tank NR PA9902 PA VCA0008 PA9903 PA WE9904 PA#	643 66 329 4,179 287 84 248 400 62 519	450 10 120 3,600 225 42 248 31 62 40	0.56 0.01 0.15 4.50 0.28 0.05 0.31 0.04 0.08 0.05	M E3 E2 E M E2 E1 M E2 E2
EIWI	243: NT/4a Mugga Ironbark - White Cypress Pine woodland on low rises mainly in the Cobar Peneplain Bioregion	40,000 (28,000 - 52,000) ha 18,000 - 32,000 ha (45 - 80 %) 280 - 340 ha (90 - 110 %)	30-70% CP 30-70% NSS <30% RIV	30-70% Lachlan <30% Murrumbidgee	CD9907 PA CD9911 PA	343 428	182 128	0.46 0.32	M M
EIWI	289: V/3a Mugga Ironbark - Scribbly Gum - Red Box shrub/grass open forest on hills in the upper slopes sub-region of the NSW South-western Slopes Bioregion	20,000 (10,000 - 30,000) ha 4,000 - 12,000 ha (20 - 60 %) 800 - 1,400 ha (71 - 120 %)	>70% NSS <30% SEH	<30% Murray 30-70% Murrumbidgee <30% Lachlan	Ellerslie NR Tumblong SCA Downfall NR Murraguldrie FR Koorawatha NR Tarcutta Hills BHR	1,879 745 483 1,520 1,111 432	250 280 13 100 320 167	1.25 1.40 0.07 0.50 1.60 0.84	E2 E1 E2 E2 E1 M
EIWI	318: V/4a Mugga Ironbark -Tumbledown Gum - Red Box - Black Cypress Pine open forest on shallow stony soils on hills in the NSW South-western Slopes Bioregion	30,000 (15,000 - 45,000) ha 6,000 - 18,000 ha (20 - 60 %) 120 - 110 ha (100 - 95 %)	>70% NSS	30-70% Murrumbidgee <30% Murray <30% Lachlan	TA9801 PA	116	116	0.39	E2
EIWI	328: LC/1a Red Ironbark - Black Cypress Pine shrubby woodland of the NSW South-western Slopes Bioregion	30,000 (27,000 - 33,000) ha 18,000 - 32,000 ha (60 - 110 %) 8,400 - 15,000 ha (70 - 130 %)	>70% NSS	30-70% Central West 30-70% Lachlan	Goobang NP	42,347	12,000	40.0	E2
EIWI	329: LC/1b Red Ironbark - Red Stringybark - Tumbledown Gum heath low woodland on siliceous ridges of the NSW central western slopes	6,000 (4,200 - 7,800) ha 3,900 - 7,100 ha (65 - 120 %) 2,500 - 4,500 ha (71 - 130 %)	>70% NSS	>70% Lachlan <30% Central West	Goobang NP	42,347	3,500	58.3	E2

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EIWI	330: NT/2a Mugga Ironbark - Black Cypress Pine - Red Stringybark - Blakelys Red Gum - Red Ironbark woodland on hillslopes and in valleys on ranges in the NSW central western slopes	30,000 (21,000 - 39,000) ha 8,400 - 15,000 ha (28 - 50 %) 3,300 - 6,100 ha (70 - 130 %)	>70% NSS	30-70% Central West 30-70% Lachlan	Goobang NP	42,347	3,300	11.0	E2
					Nangar NP	9,356	440	1.47	E1
					Weddin Mountains NP	8,697	970	3.23	E1
EIWI	342: V/3a Mugga Ironbark - mixed box woodland on hills in the Cowra - Boorowa - Young region of the NSW South-western Slopes Bioregion	12,000 (8,400 - 15,000) ha 3,500 - 6,500 ha (29 - 54 %) 810 - 980 ha (91 - 110 %)	<30% SEH >70% NSS	<30% Murrumbidgee 30-70% Lachlan	Illunie NR	732	45	0.38	E2
					Dananbilla NR	2,436	700	5.83	E1
					Goonawarra NR*	410	20	0.17	E4
					Gungewalla NR	140	10	0.08	E3
					VCA0044	46	20	0.17	E3
					VCA0033	155	100	0.83	E3
EIWI	343: E/5b Mugga Ironbark - Red Box - Red Stringybark - Inland Grey Box grass/shrub woodland on metamophic substrates in the Tarcutta - Gundagai region, NSW SWS Bioregion	4,000 (2,800 - 5,200) ha 350 - 650 ha (8.8 - 16 %) 0 ha	>70% NSS	>70% Murrumbidgee	Not Protected				
EIWI	358: CE/5b Mugga Ironbark - Red Box - White Box tall woodland on hills composed of fine-grained sediments in the Wellington to Mudgee region in the northern NSW South-western Slopes Bioregion	3,000 (2,100 - 3,900) ha 140 - 260 ha (4.7 - 8.7 %) 0 ha	>70% NSS	>70% Central West	Not Protected				
EMDI	178: E/5c Broombush - Green Mallee - Blue Mallee very tall shrubland on stony rises in the NSW South-western Slopes Bioregion	800 (560 - 1,000) ha 140 - 260 ha (18 - 33 %) 67 - 120 ha (71 - 130 %)	>70% NSS	>70% Lachlan <30% Murrumbidgee	Blue Mallee FR	66	5	0.63	E3
					Buddigower NR	329	50	6.25	E1
					The Charcoal Tank NR	84	40	5.00	E1
ESAW	303: CE/5b Black Sally grassy low woodland in valleys in the upper slopes sub-region of the NSW South-western Slopes Bioregion and western South Eastern Highlands Bioregion	5,000 (3,500 - 6,500) ha 210 - 390 ha (4.2 - 7.8 %) 0 ha	30-70% SEH <30% NSS	30-70% Murrumbidgee 30-70% Murray	Not Protected				

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ESCT	285: E/5b Broad-leaved Sally grass - sedge woodland on valley flats and swamps in the NSW South-western Slopes and adjoining South Eastern Highlands Bioregions	8,000 (5,600 - 10,000) ha 1,400 - 2,600 ha (18 - 33 %) 68 - 200 ha (50 - 150 %)	30-70% NSS 30-70% SEH	>70% Murray <30% Murrumbidgee	Bogandyera NR# Murraguldrie FR Woomargama NP Woomargama SCA	9,463 1,520 24,185 7,046	6 10 113 6	0.08 0.13 1.41 0.08	M E3 M E1
ESWWS	288: LC/1b Long-leaved Box - Black Cypress Pine granitic hillcrest shrubby open forest of the upper Murray Valley region, NSW SW Slopes Bioregion	8,000 (5,600 - 10,000) ha 4,200 - 7,800 ha (53 - 98 %) 4,000 - 4,800 ha (92 - 110 %)	>70% NSS	>70% Murray	Woomargama NP Woomargama SCA	24,185 7,046	4,224 140	52.8 1.75	E1 E1
ESWWS	290: NT/3a Red Stringybark - Red Box - Long-leaved Box - Scribbly Gum tussock grass - shrub low open forest on hills in the southern part of the NSW South-western Slopes Bioregion	30,000 (21,000 - 39,000) ha 7,000 - 13,000 ha (23 - 43 %) 1,600 - 2,900 ha (71 - 130 %)	>70% NSS <30% SEH	30-70% Murrumbidgee 30-70% Murray	Ellerslie NR Downfall NR Nest Hill NR Livingstone NP Livingstone SCA Jingellic NR	1,879 483 758 1,918 582 2,140	30 176 678 800 85 487	0.10 0.59 2.26 2.67 0.28 1.62	E2 E1 E2 E1 E1 M
ESWWS	291: NT/4b Scribbly Gum - Black Cypress Pine - Mugga ironbark - Daphne Heath low woodland of the Wagga Wagga region in the southern NSW South-western Slopes Bioregion	6,000 (5,400 - 6,600) ha 3,600 - 4,400 ha (60 - 73 %) 740 - 890 ha (91 - 110 %)	>70% NSS	30-70% Murrumbidgee <30% Murray	Livingstone NP Livingstone SCA	1,918 582	465 350	7.75 5.83	E1 E1
ESWWS	296: NT/2a Brittle Gum - peppermint open forest of the Woomargama to Tumut region, NSW South-western Slopes Bioregion	30,000 (27,000 - 33,000) ha 17,000 - 19,000 ha (57 - 63 %) 5,100 - 9,300 ha (71 - 130 %)	30-70% NSS <30% SEH	30-70% Murrumbidgee 30-70% Murray	Downfall NR Kosciuszko NP# Woomargama NP Wereboldera SCA Bogandyera NR# Mundaroo FR# Carabost FR#	483 689,464 24,185 2,255 9,463 1,946 2,803	96 5,000 335 427 454 400 500	0.32 16.7 1.12 1.42 1.51 1.33 1.67	E1 E3 E1 E1 M E3 E3

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ESWWS	297: NT/1a Broad-leaved Peppermint - Nortons Box - Red Stringybark tall open forest on red clay on hills in the southern part of the NSW South-western Slopes Bioregion	40,000 (28,000 - 52,000) ha 18,000 - 32,000 ha (45 - 80 %) 11,000 - 19,000 ha (75 - 130 %)	>70% NSS	30-70% Murrumbidgee 30-70% Murray	Bogandyera NR# Courabyra NR# Downfall NR Jingellic NR Minjary NP Mullengandra NR Woomargama NP Woomargama SCA	9,463 240 483 2,140 1,459 150 24,185 7,046	3,000 150 157 532 11 80 7,200 3,580	7.50 0.38 0.39 1.33 0.03 0.20 18.0 8.95	E2 E2 M M E1 E3 E2 E1
ESWWS	306: NT/1a Red Box - Red Stringybark - Nortons Box hill heath shrub - tussock grass open forest of the Tumut region	12,000 (8,400 - 15,000) ha 5,600 - 10,000 ha (47 - 83 %) 3,400 - 6,200 ha (71 - 130 %)	30-70% SEH 30-70% NSS	30-70% Murrumbidgee <30% Murray	Wereboldera SCA Kosciuszko NP# Mundaroo FR#	2,255 689,464 1,946	1,691 3,000 96	14.1 25.0 0.80	E1 E4 E4
ESWWS	311: NT/3b Red Stringybark - Broad-leaved Peppermint - Nortons Box heath open forest on in the upper slopes subregion in the NSW SWS Bioregion and adjoining South East Highlands Biorgion	2,000 (1,400 - 2,600) ha 840 - 1,500 ha (42 - 75 %) 460 - 550 ha (92 - 110 %)	30-70% NSS 30-70% SEH	<30% Murrumbidgee >70% Murray	Bogandyera NR# Clarkes Hill NR# Kosciuszko NP#	9,463 2,206 689,464	102 200 200	5.10 10.0 10.0	M E2 E4
ESWWS	313: LC/1c Brittle Gum - Broad-leaved Peppermint open forest with tall dense shrub understorey on riparian coarse grained granitic soils in the South-western Slopes Bioregion	300 (210 - 390) ha 210 - 390 ha (70 - 130 %) 270 - 330 ha (90 - 110 %)	>70% NSS	>70% Murray	Woomargama NP	24,185	300	100	E3
ESWWS	321: NT/3a Red Stringybark - Long-leaved Box - Black Cypress Pine shrub/grass woodland on siliceous sedimentary ranges in the upper NSW South-western Slopes and South Eastern Highlands Bioregions	23,000 (12,000 - 34,000) ha 7,500 - 22,000 ha (33 - 96 %) 2,000 - 2,400 ha (90 - 110 %)	<30% SEH >70% NSS	30-70% Central West 30-70% Lachlan	Barton NR# Conimbla NP Dananbilla NR Gungewalla NR VCA0081	533 7,948 2,436 140 224	340 1,400 200 70 200	1.48 6.09 0.87 0.30 0.87	E1 E2 E1 E1 E2

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ESWWS	322: LC/1a Scribbly Gum - Red Stringybark - Black Cypress Pine hillslope shrub-tussock grass open forest on mainly sandstone ranges in the NSW central western slopes	30,000 (15,000 - 45,000) ha 10,000 - 30,000 ha (33 - 100 %) 8,700 - 16,000 ha (70 - 130 %)	>70% NSS	30-70% Lachlan 30-70% Central West	Conimbla NP Nangar NP Weddin Mountains NP Koorawatha NR Dananbilla NR VCA0044	7,948 9,356 8,697 1,111 2,436 46	1,500 7,300 1,850 500 1,200 12	5.00 24.3 6.17 1.67 4.00 0.04	E2 E2 E1 E3 E3 E3
ESWWS	323: LC/3a Red Stringybark open forest on steep hills in the Mudgee region in the northern section of the NSW South-western Slopes Bioregion	10,000 (5,000 - 15,000) ha 3,500 - 10,000 ha (35 - 100 %) 910 - 1,600 ha (70 - 120 %)	>70% NSS	>70% Central West	Avisford NR	2,587	1,300	13.0	E2
ESWWS	324: LC/4b Scribbly Gum grassy open forest on hills in the Mudgee Region, NSW central western slopes	2,500 (1,800 - 3,200) ha 1,600 - 2,800 ha (64 - 110 %) 210 - 390 ha (70 - 130 %)	>70% NSS	>70% Central West	Avisford NR	2,587	300	12.0	E2
ESWWS	325: LC/3c Blue-leaved Stringybark open forest of the Mudgee region NSW central western slopes	300 (270 - 330) ha 230 - 270 ha (77 - 90 %) 70 - 130 ha (70 - 130 %)	>70% NSS	>70% Central West	Avisford NR	2,587	100	33.3	E2
ESWWS	327: LC/4b Scribbly Gum - Black Cypress Pine - Red Ironbark open forest of the NSW central western slopes	5,000 (3,500 - 6,500) ha 2,800 - 5,200 ha (56 - 100 %) 350 - 650 ha (70 - 130 %)	>70% NSS	30-70% Central West	Goobang NP	42,347	500	10.0	E2
ESWWS	331: LC/1a Red Stringybark woodland on siliceous hillslopes in of the Hervey Range region in the northern part of the NSW South-western Slopes Bioregion	20,000 (14,000 - 26,000) ha 12,000 - 20,000 ha (60 - 100 %) 6,700 - 12,000 ha (71 - 130 %)	>70% NSS	30-70% Central West 30-70% Lachlan	Goobang NP	42,347	9,500	47.5	E2
ESWWS	345: NT/5a Red Box - Tumbledown Gum - Red Stringybark - Long-leaved Box dry woodland on fine-grained metamorphic substrates in the western South Eastern Highlands and upper NSW South-western Slopes Bioregions	5,000 (3,500 - 6,500) ha 2,100 - 3,900 ha (42 - 78 %) 35 - 41 ha (92 - 110 %)	30-70% NSS 30-70% SEH	<30% Central West 30-70% Lachlan	Copperhannia NR#	3,507	38	0.76	M

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ESWWS	346: V/5b White Box - Blakelys Red Gum - White Cypress Pine shrubby woodland on metamorphic hills in the Wagga Wagga region of the NSW South-western Slopes Bioregion	1,500 (750 - 2,200) ha 350 - 1,000 ha (23 - 67 %) 0 ha	>70% NSS	>70% Murrumbidgee	Not Protected				
ESWWS	348: V/4a Red Stringybark - Long-leaved Box - Joycea pallida grassy open forest in the upper Lachlan catchment, NSWSWS and South Eastern Highlands Bioregions	30,000 (21,000 - 39,000) ha 8,400 - 15,000 ha (28 - 50 %) 280 - 520 ha (70 - 130 %)	30-70% NSS 30-70% SEH	>70% Lachlan	Mundoonen NR#	1,476	400	1.33	E2
ESWWS	353: CE/5b Scribbly Gum - Red Stringybark - box - Daviesia latifolia - snow grass open forest on sandy loam soils from acid volcanics in the Boorowa - Young region of the NSW South-western Slopes Bioregion	3,000 (2,100 - 3,900) ha 210 - 390 ha (7 - 13 %) 0 ha	>70% NSS	>70% Lachlan	Not Protected				
ESWWS	354: LC/1a Red Stringybark - Long-leaved Box - Black Cypress Pine - hummock grass - shrubby low woodland on siliceous volcanic and sedimentary ranges in the Peak Hill region, central west NSW	15,000 (11,000 - 19,000) ha 8,400 - 15,000 ha (56 - 100 %) 4,900 - 9,100 ha (70 - 130 %)	>70% NSS	30-70% Central West <30% Lachlan	Goobang NP	42,347	7,000	46.7	E2
EWLFST	310: LC/1a Nortons Box - Red Stringybark grassy tall open forest on sheltered slopes in the Tumbarumba - Murray River region of the NSW South-western Slopes Bioregion	10,000 (7,000 - 13,000) ha 4,200 - 7,800 ha (42 - 78 %) 6,200 - 7,400 ha (91 - 110 %)	30-70% SEH 30-70% NSS	>70% Murray <30% Murrumbidgee	Bogandyera NR# Clarkes Hill NR# Jingellic NR Carabost FR# Mundaroo FR#	9,463 2,206 2,140 2,803 1,946	4,500 44 860 1,000 400	45.0 0.44 8.60 10.0 4.00	E2 M E1 E3 E4

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EWLFST	344: E/5b Argyle Apple - Acacia mearnsii valley open forest of the Yass - Rye Park region of the South Eastern Highlands and adjoining NSW South Western Slopes Bioregions	4,500 (3,200 - 5,800) ha 910 - 1,600 ha (20 - 36 %) 130 - 220 ha (74 - 130 %)	30-70% SEH <30% NSS	<30% Murrumbidgee >70% Lachlan	Mundoonen NR# Razorback NR# Burrinjuck NR# Oak Creek NR#	1,476 2,640 5,201 403	4 10 150 12	0.09 0.22 3.33 0.27	M E3 E3 E3
EWLFST	349: LC/4a Scribbly Gum - Red Stringybark open forest on hills composed of silicous substrates in the mid-Murrumbidgee and upper Lachlan catchments mainly in the western South Eastern Highlands Bioregion	80,000 (56,000 - 100,000) ha 28,000 - 52,000 ha (35 - 65 %) 2,200 - 4,000 ha (71 - 130 %)	<30% NSS >70% SEH	30-70% Lachlan <30% Murrumbidgee	Mundoonen NR# Razorback NR# Black Andrew NR# Burrinjuck NR# Oak Creek NR#	1,476 2,640 1,557 5,201 403	830 2,000 1 3 255	1.04 2.50 <0.01 <0.01 0.32	E2 E2 M M E1
EWLFST	351: V/4a Brittle Gum - Broad-leaved Peppermint - Red Stringybark open forest in the north-western part (Yass to Orange) of the South Eastern Highlands Bioregion	50,000 (35,000 - 65,000) ha 14,000 - 26,000 ha (28 - 52 %) 70 - 1,300 ha (10 - 190 %)	>70% SEH <30% NSS	30-70% Lachlan 30-70% Central West	Mundoonen NR# Burrinjuck NR# Black Andrew NR#	1,476 5,201 1,557	1 500 190	<0.01 1.00 0.38	M E3 E2
EWRHI	185: LC/4a Dwyers Red Gum - White Cypress Pine - Currawang shrubby woodland of the NSW South-western Slopes Bioregion	50,000 (35,000 - 65,000) ha 28,000 - 52,000 ha (56 - 100 %) 910 - 1,600 ha (70 - 120 %)	<30% CP >70% NSS	<30% Lachlan <30% Murrumbidgee	Cocoparra NR* Cocoparra NP* Snake Rock AA	4,775 8,364 61	830 460 5	1.66 0.92 0.01	E1 E1 E2

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EWRHI	186: LC/1a Dwyers Red Gum - Black Cypress Pine - Currawang shrubby low woodland on rocky hills mainly in the NSW South-western Slopes Bioregion	60,000 (30,000 - 90,000) ha 25,000 - 75,000 ha (42 - 130 %) 15,000 - 27,000 ha (72 - 130 %)	<30% CP >70% NSS	30-70% Lachlan <30% Murray 30-70% Murrumbidgee	Blue Mallee FR	66	10	0.02	E3
					Cocoparra NP*	8,364	6,030	10.1	E1
					Cocoparra NR*	4,775	3,200	5.33	E1
					Eugowra NR	115	100	0.17	M
					Goobang NP	42,347	500	0.83	E1
					Ingalba NR	4,179	400	0.67	E2
					The Charcoal Tank NR	84	2	<0.01	E1
					The Rock NR	343	193	0.32	E2
					Weddin Mountains NP	8,697	5,145	8.58	E1
					Livingstone NP	1,918	300	0.50	E2
					Livingstone SCA	582	17	0.03	E1
					Boginderra Hills NR	798	320	0.53	E2
					Benambra NP	1,400	30	0.05	E2
					Tabletop NR	102	23	0.04	E3
					Koorawatha NR	1,111	420	0.70	E1
					Dananbilla NR	2,436	1,000	1.67	E1
					Woomargama NP	24,185	200	0.33	E3
					Ulandra NR	3,958	2,400	4.00	E2
					Buddigower NR	329	40	0.07	E2
					CO9801 PA	525	525	0.88	M
					VCA0044	46	12	0.02	E3
					WE9904 PA#	519	45	0.08	E3
EWRHI	257: NT/5a Dwyers Red Gum - Currawang grassy low woodland of the central western plains of NSW	45,000 (32,000 - 58,000) ha 21,000 - 39,000 ha (47 - 87 %) 330 - 330 ha (100 - 100 %)	30-70% CP 30-70% NSS	30-70% Central West <30% Lachlan <30% Western	Cocoparra NP*	8,364	330	0.73	E2
EWRHI	319: V/5a Tumbledown Gum - White Cypress Pine hill woodland in the southern part of the NSW South-western Slopes Bioregion	20,000 (10,000 - 30,000) ha 4,000 - 12,000 ha (20 - 60 %) 0 ha	>70% NSS	30-70% Murrumbidgee <30% Murray <30% Lachlan	Not Protected				
EWRHI	332: LC/3a Tumbledown Gum - Black Cypress Pine - Red Stringybark woodland on rocky hills in the NSW central western slopes	15,000 (7,500 - 22,000) ha 5,500 - 16,000 ha (37 - 110 %) 890 - 1,600 ha (71 - 130 %)	>70% NSS	30-70% Lachlan <30% Central West	Conimbla NP	7,948	500	3.33	E3
					Nangar NP	9,356	600	4.00	E2
					Boginderra Hills NR	798	160	1.07	M

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EWRHI	338: E/5b Blakelys Red Gum - Red Stringybark - Long-leaved Box woodland on Wyangala Granite in the NSW South-western Slopes Bioregion	8,000 (5,600 - 10,000) ha 720 - 880 ha (9 - 11 %) 0 ha	30-70% NSS 30-70% SEH	>70% Lachlan	Not Protected				
EWRHI	339: V/5a Tumbledown Gum - Black Cypress Pine - Red Stringybark - Currawang shrubby low woodland on Wyangala granite and metasediments of the Wyangala Dam region, NSW South-western Slopes Bioregion	20,000 (14,000 - 26,000) ha 8,400 - 15,000 ha (42 - 75 %) 5 - 5 ha (100 - 100 %)	>70% NSS	>70% Lachlan	CW9903 PA#	32	5	0.03	E2
EWRHI	340: NT/5b Red Stringybark - red gum - Black Cypress Pine - Kunzea - tea tree shrubby open forest on granite ranges of the Boorowa - Wyangala region, NSW SW Slopes Bioregion	2,000 (1,400 - 2,600) ha 700 - 1,300 ha (35 - 65 %) 0 ha	>70% NSS	>70% Lachlan	Not Protected				
FWI	053: V/4a Shallow freshwater sedge swamp in depressions on floodplains of inland north-western NSW	150,000 (75,000 - 220,000) ha 25,000 - 75,000 ha (17 - 50 %) 1,800 - 3,200 ha (71 - 130 %)	<30% BBS 30-70% DRP <30% MUL <30% RIV <30% NSS	30-70% Border R/Gwydir 30-70% Central West <30% Lachlan <30% Murray <30% Murrumbidgee <30% Namoi <30% Western	Boomi NR* Budelah NR* Kirramingly NR# Macquarie Marshes NR* Nocoleche NR* Boomi West NR* Boronga NR*	157 4,049 1,329 19,465 71,068 148 198	2 17 9 2,000 500 5 3	<0.01 0.01 0.01 1.33 0.33 <0.01 <0.01	E1 E2 M E2 E2 E1 E1
FWI	181: LC/3a Common Reed - Bushy Groundsel aquatic tall grassland of inland river systems	30,000 (15,000 - 45,000) ha 10,000 - 30,000 ha (33 - 100 %) 2,700 - 4,900 ha (71 - 130 %)	<30% CP <30% DRP <30% MUL <30% MDD <30% NSS 30-70% RIV	<30% Border R/Gwydir <30% Central West <30% Lachlan <30% Lower MD 30-70% Murray <30% Murrumbidgee <30% Namoi <30% Western	Macquarie Marshes NR* Yanga NP* Narran Lake NR*#	19,465 36,438 22,338	3,800 5 20	12.7 0.02 0.07	E2 E3 E3

Formation Group Acronym	Veg ID: Threat/Protected Area Code Plant Community Common Name	ESTIMATED EXTENT: pre-European (range) Current Range (% pre-European) Protected Range (% pre-European)	% of Community in Bioregion	% of Community in CMA	Protected Area Name & Size (ha) (* = also on Western Slopes) (# = also on Tablelands or Northern Slopes)		Veg Area (ha) % Pre-European & Accuracy Code		
FWI	182: LC/4a Cumbungi rushland of shallow semi-permanent water bodies of the inland river systems	40,000 (12,000 - 68,000) ha 15,000 - 45,000 ha (38 - 110 %) 200 - 600 ha (50 - 150 %)	<30% DRP <30% MUL <30% MDD <30% NSS 30-70% RIV	<30% Border R/Gwydir <30% Central West <30% Lachlan <30% Lower MD <30% Murray <30% Murrumbidgee <30% Namoi <30% Western	Macquarie Marshes NR*	19,465	400	1.00	E2
FWI	238: NT/5a Permanent and semi-permanent freshwater lakes of the inland slopes and plains	1,000,000 (500,000 - 1,500,000) ha 200,000 - 600,000 ha (20 - 60 %) 710 - 2,100 ha (51 - 150 %)	<30% BBS >70% DRP <30% MUL <30% MDD <30% NSS 30-70% RIV <30% SSD	<30% Border R/Gwydir <30% Central West <30% Lachlan <30% Lower MD <30% Murray <30% Murrumbidgee <30% Namoi <30% Western	Billabong FR* Macquarie Marshes NR* Moira Lakes FR* Morrisons Lake NR* Peacock Creek FR* Pollack FR* Willandra NP* Yanga NP*	309 19,465 1,418 319 110 714 18,835 36,438	19 300 664 180 5 6 100 130	<0.01 0.03 0.07 0.02 <0.01 <0.01 0.01 0.01	E1 E3 E1 E2 E2 E1 E4 E2
FWI	360: CE/5c Gilgai wetland mosaic in the southern NSW South-western Slopes Bioregion	1,000 (500 - 1,500) ha 70 - 130 ha (7 - 13 %) 0 ha	>70% NSS	>70% Murray <30% Murrumbidgee	Not Protected				
FWSS	335: E/5b Tussock grass - sedge - rush - reed valley flat wetlands on organic clay loams in the upper slopes sub-region of the NSW South-western Slopes Bioregion	6,000 (3,000 - 9,000) ha 700 - 1,300 ha (12 - 22 %) 0 ha	30-70% NSS <30% SEH	<30% Lachlan <30% Central West <30% Murrumbidgee <30% Murray	Not Protected				
FWSS	336: NT/5b Rush - Sedge - Common Reed mainly lentic channel wetlands of the Upper Murray and mid-Murrumbidgee River floodplains in the NSW South-western Slopes Bioregion	3,000 (2,100 - 3,900) ha 1,100 - 1,900 ha (37 - 63 %) 4 - 4 ha (90 - 110 %)	>70% NSS <30% RIV <30% SEH	>70% Murray <30% Murrumbidgee	VCA0084	14	4	0.13	E4
GFTI	250: LC/2b Derived tussock grasslands of the central western plains and lower slopes of NSW	1,000 (100 - 1,900) ha 200,000 - 600,000 ha (20000 - 60000 %) 430 - 510 ha (91 - 110 %)	<30% CP 30-70% NSS	30-70% Central West 30-70% Lachlan <30% Murrumbidgee <30% Western	CD9907 PA CD9911 PA VCA0008	343 428 400	122 260 90	12.2 26.0 9.00	M M E1

Formation Group Acronym	Veg ID: Threat/Protected Area Code Plant Community Common Name	ESTIMATED EXTENT: pre-European (range) Current Range (% pre-European) Protected Range (% pre-European)	% of Community in Bioregion	% of Community in CMA	Protected Area Name & Size (ha) (* = also on Western Slopes) (# = also on Tablelands or Northern Slopes)		Veg Area (ha) % Pre-European & Accuracy Code		
GFTI	320: CE/5a Kangaroo Grass - Redleg Grass rich-herb temperate tussock grassland of the northern Monaro, ACT and upper Lachlan River regions of the NSW South Western Slopes and South Eastern Highlands Bioregions	25,000 (18,000 - 32,000) ha 700 - 1,300 ha (2.8 - 5.2 %) 0 ha	<30% NSS >70% SEH	>70% Lachlan	Not Protected				
HSOT	292: LC/2b She oak - Fringe Myrtle heathland on rocky ranges in the NSW South-western Slopes Bioregion	8,000 (5,600 - 10,000) ha 4,200 - 7,800 ha (53 - 98 %) 2,100 - 3,800 ha (71 - 130 %)	>70% NSS	30-70% Lachlan <30% Murrumbidgee <30% Central West	Big Bush NR	643	170	2.13	E1
					Pucawan NR	287	30	0.38	E1
					Ingalba NR	4,179	350	4.38	E1
					Nangar NP	9,356	36	0.45	E1
					Goobang NP	42,347	2,000	25.0	E2
					Conimbla NP	7,948	360	4.50	E1
					Dananbilla NR	2,436	20	0.25	E3
					Koorawatha NR	1,111	5	0.06	E3
					Gungewalla NR	140	2	0.03	E3
HSOT	301: E/5b Drooping Sheoke - Ricinocarpus bowmannii - grasstree tall open shrubland of the Coolac - Tumut Serpentinite Belt	8,500 (6,000 - 11,000) ha 1,700 - 3,100 ha (20 - 36 %) 0 ha	>70% NSS <30% SEH	>70% Murrumbidgee	Not Protected				
HSOT	334: LC/3c Tick Bush - Drooping She Oak tall shrubland on granite hills of the NSW central western slopes	800 (720 - 880) ha 630 - 770 ha (79 - 96 %) 200 - 370 ha (70 - 130 %)	>70% NSS	>70% Lachlan	Boginderra Hills NR	798	285	35.6	E2
HSOT	337: CE/5c Apple Box - Silver Banksia - Drooping Sheoak open woodland - tall shrubland in protected gullies of the Coolac - Tumut serpentinite belt, NSW South-western Slopes Bioregion.	300 (210 - 390) ha 27 - 33 ha (9 - 11 %) 0 ha	>70% NSS	>70% Murrumbidgee	Not Protected				

Formation Group Acronym	Veg ID: Threat/Protected Area Code Plant Community Common Name	ESTIMATED EXTENT: pre-European (range) Current Range (% pre-European) Protected Range (% pre-European)	% of Community in Bioregion	% of Community in CMA	Protected Area Name & Size (ha) (* = also on Western Slopes) (# = also on Tablelands or Northern Slopes)		Veg Area (ha) % Pre-European & Accuracy Code		
HSOT	357: LC/5c Beyeria - Mintbush - Tumbledown Gum shrubland - low woodland on conglomerate outcrops in the Wellington region, NSW central western slopes	100 (70 - 130) ha 56 - 100 ha (56 - 100 %) 0 ha	>70% NSS	>70% Central West	Not Protected				
MWSI	173: NT/2a Sandplain mallee of central NSW	700,000 (490,000 - 910,000) ha 250,000 - 450,000 ha (36 - 64 %) 120,000 - 130,000 ha (98 - 110 %)	<30% CP 30-70% MDD <30% NSS	<30% Central West 30-70% Lachlan <30% Murrumbidgee <30% Western	Gubbata NR*	151	146	0.02	E1
					Kajuligah NR*	13,833	4,000	0.57	E3
					Langtree NR*	232	32	<0.01	E1
					Loughnan NR*	390	360	0.05	E1
					Mount Grenfell HS*	1,365	100	0.01	E2
					Nombinnie NR*	72,128	57,590	8.23	E1
					Nombinnie SCA*	53,258	33,830	4.83	E2
					Pulletop NR*	145	135	0.02	E1
					Round Hill NR*	13,642	12,540	1.79	E1
					Scrubby Mountain FR*	1,704	250	0.04	E3
					Yathong NR*	108,768	13,400	1.91	E2
					WE9906 PA#	24	24	<0.01	M
					WE9907 PA#	519	35	0.01	M
MWSI	193: E/3a Red Mallee - White Mallee extremely tall "tree mallee" on silty-loam-clay soils of central south-western NSW	20,000 (10,000 - 30,000) ha 2,500 - 7,500 ha (13 - 38 %) 1,100 - 1,900 ha (73 - 130 %)	<30% CP 30-70% MDD <30% NSS	<30% Central West 30-70% Lachlan <30% Western	Nombinnie NR*	72,128	500	2.50	E1
					Nombinnie SCA*	53,258	1,000	5.00	E1
					Quanda NR*	4,767	10	0.05	E4
MWSI	355: CE/5b Bull Mallee - White Mallee tall mallee woodland on red sandy loam soils in the central western slopes of NSW	2,000 (1,800 - 2,200) ha 90 - 110 ha (4.5 - 5.5 %) 0 ha	>70% NSS	>70% Lachlan	Not Protected				
MWSR	176: LC/3a Green Mallee - White Cypress Pine very tall mallee woodland on gravel rises mainly in the Cobar Peneplain Bioregion	75,000 (53,000 - 97,000) ha 42,000 - 78,000 ha (56 - 100 %) 5,000 - 9,200 ha (70 - 130 %)	>70% CP <30% MDD <30% NSS	30-70% Central West <30% Lachlan 30-70% Western	Nombinnie SCA*	53,258	260	0.35	M
					Yathong NR*	108,768	6,800	9.07	E2
					CD9907 PA	343	2	<0.01	M
					CD9911 PA	428	21	0.03	M
					WE9902 PA#	519	40	0.05	E1

Formation Group Acronym	Veg ID: Threat/Protected Area Code Plant Community Common Name	ESTIMATED EXTENT: pre-European (range) Current Range (% pre-European) Protected Range (% pre-European)	% of Community in Bioregion	% of Community in CMA	Protected Area Name & Size (ha) (* = also on Western Slopes) (# = also on Tablelands or Northern Slopes)		Veg Area (ha) % Pre-European & Accuracy Code		
MWSR	177: E/4a Blue Mallee - Bull Mallee - Green Mallee very tall mallee shrubland of the West Wyalong region, NSW South-western Slopes Bioregion	15,000 (11,000 - 19,000) ha 1,400 - 2,600 ha (9.3 - 17 %) 150 - 170 ha (94 - 110 %)	>70% NSS	>70% Lachlan <30% Murrumbidgee	Big Bush NR Blue Mallee FR Buddigower NR	643 66 329	5 40 115	0.03 0.27 0.77	E3 E2 E2
MWSR	256: LC/5b Green Mallee - Black Cypress Pine tall mallee woodland on rises and low hills in the central western slopes of NSW	7,000 (3,500 - 10,000) ha 2,500 - 7,500 ha (36 - 110 %) 59 - 71 ha (91 - 110 %)	<30% BBS <30% CP 30-70% NSS	>70% Central West <30% Lachlan <30% Western	Big Bush NR Coolbaggie NR#	643 1,773	15 50	0.21 0.71	E3 E2
RIEC	302: V/5b Riparian Blakelys Red Gum - Broad-leaved Sally woodland - tea-tree - bottlebrush - wattle shrubland of the NSW South-western Slopes and South East Highlands Bioregions	5,000 (2,500 - 7,500) ha 1,300 - 3,700 ha (26 - 74 %) 63 - 350 ha (30 - 170 %)	30-70% NSS 30-70% SEH	30-70% Murrumbidgee <30% Murray	Bogandyera NR# Kosciuszko NP#	9,463 689,464	10 200	0.20 4.00	E3 E3
RIEC	333: V/5c Bottlebrush riparian shrubland of the central western slopes and adjoining tablelands of NSW	3,000 (1,500 - 4,500) ha 500 - 1,500 ha (17 - 50 %) 2 - 9 ha (30 - 170 %)	>70% NSS <30% SEH	30-70% Lachlan 30-70% Central West	Nangar NP	9,356	5	0.17	E3

NSWSWS Bioregion plant communities

A total of 135 plant communities have been classified and assessed as being in the NSWSWS Bioregion. Plant community ID number, common name, extent, threat category and protected area occurrences and status are listed in Table 1. A total of 97 of the communities are additions to the plant communities described in Part 1 of the NSWVCA project in Benson et al. (2006). A total of 38 NSWSWS communities also occur in the NSW Western Plains (Table 1). Examples of full reports and short reports of plant communities from the NSWSWS Bioregion in the NSWVCA database are provided in Appendices A–D.

The bulk of the results, i.e. the plant community descriptions, are presented in reports generated from Version 2 of the NSWVCA database. These reports are arranged in folders on the CD accompanying the article. They include full (90 field) and short (28 field) reports covering the 135 plant communities in the NSWSWS Bioregion. The full PDF report on the NSWSWS is nearly 400 pages long. The CD contains a "read only" copy of Version 2 of the NSWVCA database that can be used to generate a range of full or short reports for listing plant communities by various geographical areas or under broad vegetation classes.

The contents of the CD

A **READ ME** file that describes the contents of the CD, the 15 files that comprise the NSWVCA database and explains how to use the database.

Folder 1: Version 2 of the NSWVCA database

A read-only formatted Version 2 of the NSWVCA database and 15 associated files for using the database and the *Images* folder that links to the database. This version of the database includes data entries for the NSWSWS Bioregion along with updated entries for the NSW Western Plains. In total 315 plant communities are recorded 135 or which occur in the NSWSWS Bioregion;

Folder 2: Reports on plant communities in the NSWSWS Bioregion

Full and Short PDF Reports listing the plant communities in the NSWSWS Bioregion;
Full and Short PDF Reports listing the plant communities in the Lower Slopes and Upper Slopes Sub-regions;
Updated Bibliography from Version 2 of the NSWVCA database;
PDF copy of this third NSWVCA paper: Benson, J.S. (2008) New South Wales Vegetation Classification and Assessment: Version 2: NSW South-western Slopes Bioregion and Update of NSW Western Plains. *Cunninghamia* 10(4): 599–673.

Folder 3: Updated reports on plant communities in the NSW Western Plains

This updates reports published on the CD in Benson et al. (2006) and includes:
A spreadsheet listing the changes made to the NSW Western Plains plant communities since Version 1 of the database was published in July 2006;
Full Report (all 90 fields in the database) of 220 plant communities in the NSW Western Plains;
Short Report (28 of the 90 fields) of 220 plant communities in the NSW Western Plains;
A sub-folder containing Full and Short Reports of the plant communities in each of the eight IBRA Bioregions that comprise the NSW Western Plains.

Folder 4: Reports on plant communities in six western NSW CMA areas

Updated Full and Short Reports listing plant communities in the Western CMA and the Lower Murray Darling CMA areas. The NSWVCA covers these areas completely;
Full and Short Reports listing plant communities in the NSW Western Plains and NSW Western Slopes sections of the Murray, Murrumbidgee, Lachlan and Central West CMAs. Note: plant communities in the NSW Tablelands Section (shown in Figures 6 & 8 on pages 335, 336 in Benson 2006) of these four CMA have not yet been classified or assessed in the NSWVCA project, therefore, the vegetation classification of these four CMAs remains incomplete as of 2008.
The plant communities listed in reports for bioregions or CMAs on the CD are arranged in alphabetical order by the names of the NSWVCA Formation Groups listed in Table 4 on page 346 in paper one in the NSWVCA series (Benson 2006).

Range of plant communities

Of the 135 plant communities, 9 are estimated to have had a pre-European extent <1000 ha (rare); 41 between 1000 and 10,000 ha (restricted); and 85 >10,000 ha (Table 2). Therefore, the majority of communities covered large areas before clearing and fragmentation after European settlement.

About one third (21) of the (higher hierarchical) NSWVCA Formation Groups in NSW (Table 4 on page 346 in Benson 2006), occur in the NSW SWS Bioregion (Table 3). The two Formation Groups containing the largest number of plant communities are: "*Eucalyptus* (Mostly Shrubby) Woodlands and Forests on Low Fertility Soils on the Western Slopes" with 20 communities and "*Eucalyptus* (Mostly Grassy) Box Woodlands of the Tablelands and Western Slopes" with 34 communities (Table 3). This reflects the dominance of *Eucalyptus*–dominated forests and woodlands in the NSWSWS Bioregion compared to the range of vegetation formations that occur on the NSW Western Plains where a high number of plant communities occur in chenopod shrublands, *Acacia* shrublands and grasslands (Benson et al. 2006).

A total of 20 of the 99 Vegetation Classes in defined Keith (2004) occur in the NSWSWS Bioregion (Table 4). Three of these Classes: Western Slopes Dry Sclerophyll Forests, Upper Riverina Dry Sclerophyll Forest and Western Slopes Grassy Woodlands, contain half (71 of 135) of the NSWVCA plant communities defined in the Bioregion. It should be noted that some of the Keith (2004) Vegetation Classes mainly occur outside the NSWSWS Bioregion.

The occurrence of plant communities in the four CMAs that intersect with the NSWSWS Bioregion (Central West, Lachlan, Murrumbidgee and Murray CMAs) are provided in Table 5. This table also includes an updated list of communities recorded in the two far western NSW CMAs being the Lower Murray-Darling and Western CMAs thus updating Table 8 in Version 1 of the NSWVCA presented in Benson et al. (2006).

The main vegetation types in the NSWSWS Bioregion include mallee shrublands, various types of wetlands, *Callitris*-woodlands, *Allocasuarina – Casuarina* woodlands, *Eucalyptus* grassy woodlands on higher nutrient soils, *Eucalyptus* shrubby woodlands and open forests on medium to poor soils on rocky hills and *Eucalyptus* tall open forests with fern-grass-shrub ground covers in regions with higher rainfall. The combination of different climate, substrates and soils is reflected in markedly different vegetation types from both sub-regions. The Upper Slopes Sub-region receives higher rainfall and has lower average temperatures than the Lower Slopes Sub-region.

Plant communities in the Lower Slopes Sub-region

The Lower Slopes Sub-region contains extensive alluvial plains and floodplains that support vegetation types that overlap with those described occurring in the NSW Western Plains described in Benson et al. (2006). The plant communities occurring in this sub-region are listed in Folder 2 on the CD and are summarised below.

Rivers and channels are generally dominated by *Eucalyptus camaldulensis* (River Red Gum) tall forest or tall woodland extending onto the inner floodplains (IDs 2, 5, 9) and onto the fringes or beds of cowals (lakes) or flood channels (ID249)(Figure 7). River Red Gum often mixes with riparian *Eucalyptus microcarpa* (Inland Grey Box) woodland

Table 2. Number of plant communities that are estimated to have been Originally Rare <1000 ha, Originally Restricted 1000 – 10,000 ha and Originally Common >10,000 ha before European settlement.

Estimated pre-European Extent	Community ID Numbers	Number of plant communities
RARE (<1,000 ha)	178, 293, 313, 314, 315, 325, 334, 337, 357	***9***
Restricted (1,000 - <2,000 ha)	250, 317, 346, 356, 360	5
Restricted (2,000 - <5,000 ha)	269, 284, 286, 307, 311, 324, 333, 336, 340, 343, 344, 353, 355, 358	14
Restricted (5,000 - <10,000 ha)	48, 249, 256, 274, 275, 285, 288, 291, 292, 298, 299, 301, 302, 303, 316, 326, 327, 329, 335, 338, 341, 345	22
TOTAL RESTRICTED (1,000 - <10,000 ha)		***41***
Common (10,000 - <20,000 ha)	5, 177, 237, 270, 279, 294, 304, 305, 306, 310, 323, 332, 342, 347, 350, 354	16
Common (20,000 - <50,000 ha)	2, 9, 54, 74, 77, 79, 83, 85, 110, 181, 182, 193, 243, 251, 257, 258, 272, 273, 276, 278, 281, 283, 289, 290, 295, 296, 297, 309, 312, 318, 319, 320, 321, 322, 328, 330, 331, 339, 348	39
Common (50,000 - <100,000 ha)	176, 185, 186, 217, 248, 267, 268, 280, 282, 287, 349, 351, 352	13
Common (100,000 - <200,000 ha)	53, 75, 201, 300	4
Common (200,000 - <500,000 ha)	55, 56, 57, 70, 82	5
Common (>=500,000 ha)	26, 76, 80, 173, 238, 244, 266, 277	8
TOTAL COMMON (>=10,000 ha)		***85***

(ID237). *Eucalyptus melliodora* (Yellow Box) woodland (ID74) also mixes with River Red Gum on floodplains and Yellow Box woodland also occurs on alluvial and aeolian soil flats (ID276) where it has mainly been cleared (Figure 8). Above the floodplains, Inland Grey Box tall grassy or shrub-grass woodlands (IDs 76, 80, 82, 248) (Figure 9) are common on loams and clay soils throughout the western half of the bioregion mixing with *Callitris endlicheri* (Black Cypress Pine) and shrubs on the footslopes of hills (ID110). A restricted and highly threatened Yellow Box – White Cypress Pine woodland occurs on sandy rises between Narrandera and Urana (ID75) (Figure 10). *Eucalyptus populneus* (Poplar Box) woodland (ID56, 244) is restricted to the north-western part of the NSWSWS Bioregion and is more common in bioregions to the north and west (see Benson et al. 2006). *Eucalyptus conica* (Fuzzy Box) woodland (ID201) (Figure 28, pp438 in Benson et al. 2006) occurs on alluvial or colluvial soils on flats often near watercourses in the northern half of the bioregion, often mixing with Yellow Box woodland.

Acacia shrublands include *Acacia pendula* (Weeping Myall) low woodland on alluvial plains (ID26) with small patches of *Acacia homalophylla* (Yarran) tall shrubland (ID77) on aeolian or alluvial sediments (Figure 11). *Acacia doratoxylon* (Currawang) dominated shrublands (ID317) occur on skeletal lithosol soil on rocky ridges. These grade into the more widespread *Eucalyptus dwyeri* (Dwyer's Red Gum)-dominated low woodlands (IDs 185, 186) on rocky siliceous ridges. ID185 may grade into a *Eucalyptus intertexta* (Gum Coolabah) woodland that occurs with *Eucalyptus sideroxylon* (Mugga Ironbark) and *Callitris glaucophylla* (White Cypress

Table 3. Cross reference of 135 plant communities in the NSW South-western Slopes Bioregion with 20 NSWVCA Formation Groups that occur in that bioregion.

Formation Group	Acronym	SWS VCA Veg. ID Numbers	No.
Acacia Woodlands and Shrublands of the Inland Slopes and Plains	ASI	26, 77, 317	3
Casuarina Woodlands of the Inland Slopes and Plains	CCI	54, 55, 57, 85	4
Cypress Pine (Callitris) Woodlands Mainly of the Inland	CPW	48, 70, 309	3
Eremophila, Melaleuca and Dodonaea Shrublands of the Inland	EMDI	178	1
Eucalyptus (Mostly Grassy) Box Woodlands of the Inland Plains	EBWP	56, 75, 76, 80, 82, 83, 110, 201, 244, 248, 258	11
Eucalyptus (Mostly Grassy) Box Woodlands of the Tablelands and Western Slopes	EBWT	266, 267, 268, 269, 270, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 286, 287, 293, 294, 298, 304, 305, 312, 314, 315, 316, 326, 341, 347, 350,	34
Eucalyptus (Mostly Shrubby) Woodlands and Forests on Low Fertility Soils on the Eastern Tablelands	EWLFST	310, 344, 349, 351	4
Eucalyptus (Mostly Shrubby) Woodlands and Forests on Low Fertility Soils on the Western Slopes	ESWWS	288, 290, 291, 296, 297, 306, 311, 313, 321, 322, 323, 324, 325, 327, 331, 345, 346, 348, 353, 354	20
Eucalyptus Communities of Inland Watercourses and Inner Floodplains	EIW	2, 5, 9, 74, 79, 237, 249, 251, 356	9
Eucalyptus Ironbark Woodlands and Forests of the Inland Slopes, Plains and Peneplains	EIWI	217, 243, 289, 318, 328, 329, 330, 342, 343, 358	10
Eucalyptus Subalpine Woodlands and Forests	ESAW	303	1
Eucalyptus Swamp Communities of the Eastern Coast and Tablelands	ESCT	285	1
Eucalyptus Tall Wet Forests of the Eastern Tablelands and Western Slopes	ECT	295, 299, 300, 307	4
Eucalyptus Woodlands on Rocky Hills of the Inland	EWRHI	185, 186, 257, 319, 332, 338, 339, 340	8
Freshwater Wetlands: Coast, Tablelands and Slopes Sedgeland Swamps	FWSS	335, 336	2
Freshwater Wetlands: Inland Aquatic, Swamp and Shrubland Communities	FWI	53, 181, 182, 238, 360	5
Grasslands on Fine Texture Soils on the Inland Slopes and Plains	GFTI	250, 320	2
Heaths and Shrublands on the Tablelands and Western Slopes of South-eastern Australia	HSOT	292, 301, 334, 337, 357	5
Mallee Woodlands and Shrublands of Inland Sandplains and Sand Dunes	MWSI	173, 193, 355	3
Mallee Woodlands and Shrublands on Stony Ridges of the Inland Slopes and Plains	MWSR	176, 177, 256	3
Riparian mostly Myrtaceous Shrublands of the Western Slopes, Tablelands and Coast (non-rainforest)	RIEC	302, 333	2

Pine) at the base on the slopes of granite hills in the Peak Hill to Tullamore region (ID258). A grassy Dwyer's Red Gum woodland (ID257) is present on some hills with richer soils in a few western ranges. Small areas of *Allocasuarina luehmannii* (Buloke) – *Callitris glaucophylla* (White Cypress Pine) woodland (ID54) occur on alkaline outwash soils, such as on the western flank of Goobang National Park. *Casuarina cristata* (Belah) woodlands (ID55, 56) occur on alluvial plains while *Callitris glaucophylla* (White Cypress Pine) (IDs 70 and 48) woodlands occur on alluvial or aeolian sand rises in the north mixing with red gum *Eucalyptus blakelyi / E. chloroclada* along sandy watercourses (ID356).

Ironbark woodlands are less common in the Lower Slopes Sub-region than the Upper Slopes Sub-region. Small areas of *Eucalyptus sideroxylon* (Mugga Ironbark) – *Callitris glaucophylla* (White Cypress Pine) with the mallee *Eucalyptus dumosa* (ID243) occur on gravely ridges in the north-western corner of the sub-region being more abundant in the Cobar Peneplain Bioregion. This has some similarity with the Gum Coolabah community on granite ID258 described above. A distinctive Mugga Ironbark – *Eucalyptus macrocarpa* (Inland Grey Box) woodland with a shrubby understorey (ID217) including *Acacia hakeoides*, *Dodonaea viscosa* subsp. *spatulata* and *Santalum acuminatum* is common on stony rises and footslopes of low hills in the Temora to Wyalong region (Figure 12). A good example is in The Charcoal Tank Nature Reserve.

Several mallee shrublands / low woodlands occur near the western edge of the Lower Slopes Sub-region. These include the sandplain mallee of central NSW (ID173), a very tall mallee community on loam to clay soils in central NSW (ID193), a very restricted type of mallee on parna sediment near Wyalong (ID355) (Figure 13) and / low mallee woodland on gravely rises and sediments that is dominated by *Eucalyptus polybractea* (Blue Mallee), *Eucalyptus viridis*

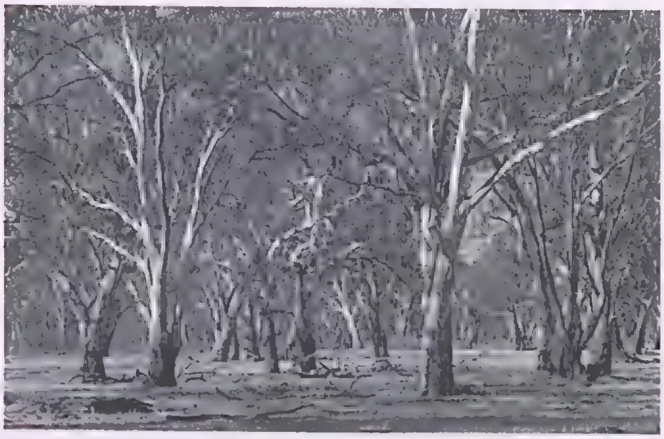

Fig. 7. ID249 *Eucalyptus camaldulensis* (River Red Gum) woodland, Gum Swamp near Walla Walla, (AGD66) 35°49'25' S 147°04'30' E. Photograph, Jaime Plaza, 19/10/2002.

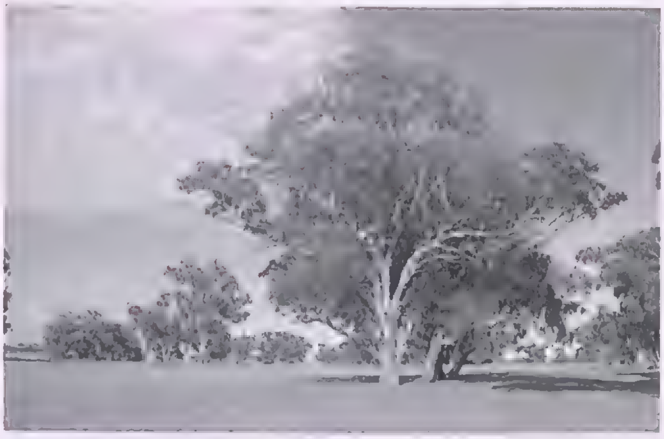

Fig. 8. ID276: An overgrazed *Eucalyptus melliodora* (Yellow Box) alluvial flats woodland on red loam soil, during a drought, north of Junee. Mainly cleared and endangered. Photograph, John Benson, 14/3/2007.

Table 4. Cross reference of the 135 plant communities classified in the NSW South-western Slopes Bioregion in the NSWVCA database with the 20 Vegetation Classes fully or partly mapped in the bioregion by Keith (2004). Other plant communities that occur in other bioregions occur in these Vegetation Classes.

Vegetation Class (Keith 2004)	SWS VCA Veg. ID Numbers	Total
Brigalow Clay Plain Woodlands	55	1
Eastern Riverine Forests	85	1
Floodplain Transition Woodlands	56, 74, 76, 80, 82, 237, 248, 251	8
Inland Floodplain Swamps	53, 181, 182, 238, 335, 336, 360	7
Inland Floodplain Woodlands	83	1
Inland Riverine Forests	2, 5, 9, 79, 249, 356	6
Inland Rocky Hill Woodlands	176, 185, 256, 257, 258, 292, 317, 318, 319, 328, 329, 332, 334, 357	14
North-west Plain Shrublands	77	1
Riverine Plain Woodlands	26	1
Riverine Sandhill Woodlands	48, 75	2
Sand Plain Mallee Woodlands	173, 193, 355	3
Semi-arid Sand Plain Woodlands	57	1
Southern Tableland Dry Sclerophyll Forests	296, 299, 307, 344, 345, 349, 351, 352	8
Southern Tableland Grassy Woodlands	283, 303, 312, 341, 350	5
Southern Tableland Wet Sclerophyll Forests	295, 300	2
Upper Riverina Dry Sclerophyll Forests	269, 285, 288, 289, 290, 293, 294, 297, 298, 302, 304, 305, 306, 310, 311, 313, 314, 315, 338, 339, 340, 342, 353	23
Western Peneplain Woodlands	70, 244	2
Western Slopes Dry Sclerophyll Forests	54, 110, 177, 178, 186, 217, 243, 270, 273, 287, 291, 309, 321, 322, 323, 324, 325, 327, 330, 331, 333, 343, 346, 348.	26
Western Slopes Grasslands	250, 320	2
Western Slopes Grassy Woodlands	201, 266, 267, 268, 272, 274, 275, 276, 277, 278, 279, 280, 281, 282, 284, 286, 301, 316, 326, 337, 347	21

(Green Mallee), *Eucalyptus behriana* (Bull Mallee) with patches of *Melaleuca uncinata* (Broombush) (Figure 14) near West Wyalong (IDs 177 & 178). Very small patches of Green Mallee woodland (ID256) occur on stony rises just within the western edge of the NSWSWS Bioregion.

An *Allocasuarina diminuta* (she oak) – *Calytrix tetragona* (Five Fringe Myrtle) shrubland (ID292) (Figure 15) occurs on rock platforms or stony rises in the central part of the Lower Slopes and Upper Slopes Sub-regions. A very restricted *Kunzea* sp. '*Mt Kaputar*' (tick bush) shrubland (ID334) occurs on granite rock platforms on ridges in the Boginderra Hills near Temora.

Limited areas of sedge / rush swamps dominated by *Eleocharis*, *Carex*, *Juncus* and other water plants (ID53 & ID360) along with Reedland (ID181) and Rushland (ID182) swamps and open water wetlands (ID238) occur throughout the Lower Slopes Sub-region.

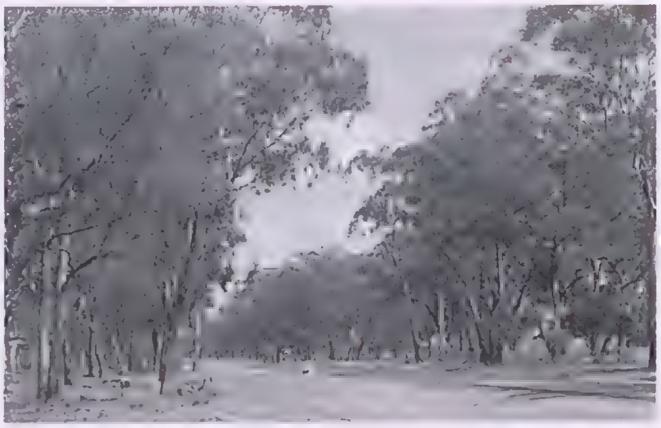

Fig. 9. ID76: *Eucalyptus microcarpa* (Inland Grey Box) tall woodland on clay to loam alluvial soils, Bimbi Road TSR South of Grenfell, (AGD66) 34°01'09" S 147°50'13" E. This is mainly cleared and endangered. Photograph, Jaime Plaza, 12/10/2002.

Table 5. Occurrence of plant communities in the eight western NSW Catchment Management Authority areas (CMAs). Notes. This updates the Western and Lower Murray Darling CMA data published in Table 8 in Version 1 of the NSWVCA (Benson et al. 2006). The Lower Murray-Darling and Western CMAs are fully covered by the NSWVCA but the Murray, Murrumbidgee, Lachlan and Central West CMAs do not include plant communities that are restricted to the South East Highlands and Australian Alps Bioregions.

CMA & No. Communities Present	Vegetation Communities Present
Central West **120**	24; 26; 27; 35; 36; 37; 39; 40; 43; 45; 49; 50; 53; 54; 55; 56; 57; 70; 77; 78; 81; 82; 83; 84; 87; 88; 98; 103; 104; 105; 106; 108; 109; 112; 125; 134; 141; 144; 145; 146; 153; 158; 160; 163; 168; 173; 174; 175; 176; 180; 181; 182; 184; 187; 188; 193; 195; 201; 202; 204; 206; 208; 211; 212; 214; 217; 227; 228; 238; 241; 242; 244; 247; 248; 249; 250; 255; 256; 257; 258; 266; 267; 268; 270; 271; 272; 273; 274; 275; 276; 277; 278; 279; 280; 281; 282; 283; 287; 292; 317; 321; 322; 323; 324; 325; 326; 327; 328; 329; 330; 331; 332; 333; 335; 345; 351; 354; 356; 357; 358
Lachlan **137**	2; 5; 7; 9; 10; 11; 12; 13; 15; 16; 17; 18; 23; 24; 26; 28; 29; 45; 46; 47; 50; 53; 54; 55; 56; 57; 58; 70; 72; 74; 76; 77; 79; 80; 82; 85; 98; 103; 104; 105; 106; 108; 110; 134; 142; 143; 153; 154; 157; 159; 160; 163; 164; 165; 166; 170; 171; 173; 174; 175; 176; 177; 178; 180; 181; 182; 184; 185; 186; 190; 193; 201; 208; 216; 217; 236; 237; 238; 239; 240; 242; 243; 244; 248; 249; 250; 251; 256; 257; 266; 267; 268; 271; 272; 275; 276; 277; 278; 279; 280; 282; 283; 287; 289; 292; 309; 317; 318; 319; 320; 321; 322; 328; 329; 330; 331; 332; 333; 334; 335; 338; 339; 340; 341; 342; 344; 345; 347; 348; 349; 350; 351; 352; 353; 354; 355; 356
Lower Murray/Darling **60**	8; 11; 12; 13; 15; 16; 17; 18; 20; 21; 22; 23; 24; 28; 41; 50; 58; 63; 64; 65; 108; 119; 123; 124; 128; 139; 143; 150; 151; 152; 153; 154; 155; 156; 157; 159; 160; 163; 164; 165; 166; 170; 171; 172; 181; 182; 189; 190; 191; 196; 199; 216; 220; 221; 238; 240; 242; 252; 253; 254
Murray **97**	2; 5; 7; 8; 9; 10; 11; 12; 13; 15; 16; 17; 18; 19; 20; 21; 22; 23; 24; 26; 28; 44; 45; 46; 47; 48; 50; 53; 58; 63; 74; 75; 76; 77; 79; 80; 86; 110; 157; 159; 160; 163; 164; 166; 170; 171; 181; 182; 186; 216; 237; 238; 240; 242; 249; 266; 267; 268; 269; 277; 282; 283; 284; 285; 286; 287; 288; 289; 290; 291; 293; 294; 295; 296; 297; 298; 299; 300; 302; 303; 304; 305; 306; 307; 309; 310; 311; 312; 313; 314; 315; 317; 318; 319; 335; 336; 360
Murrumbidgee **119**	2; 5; 7; 9; 10; 11; 12; 13; 15; 16; 17; 18; 19; 21; 23; 24; 26; 28; 44; 45; 46; 47; 48; 50; 53; 57; 58; 74; 75; 76; 77; 79; 80; 82; 85; 110; 139; 142; 143; 153; 154; 157; 159; 160; 163; 164; 165; 166; 170; 171; 173; 177; 178; 181; 182; 185; 186; 190; 216; 217; 236; 237; 238; 239; 240; 242; 243; 249; 250; 266; 267; 268; 276; 277; 278; 280; 282; 283; 284; 285; 287; 289; 290; 291; 292; 294; 295; 296; 297; 298; 299; 300; 301; 302; 303; 305; 306; 307; 309; 310; 311; 312; 316; 317; 318; 319; 335; 336; 337; 341; 342; 343; 344; 346; 347; 349; 350; 352; 360
Western **153**	11; 13; 15; 16; 18; 23; 24; 25; 27; 29; 31; 35; 36; 37; 38; 39; 40; 41; 43; 50; 52; 53; 55; 56; 57; 58; 59; 60; 61; 62; 63; 66; 67; 68; 69; 71; 72; 77; 82; 87; 98; 100; 103; 104; 105; 106; 108; 109; 115; 117; 118; 119; 120; 121; 122; 123; 124; 125; 127; 128; 129; 130; 131; 132; 133; 134; 136; 137; 138; 139; 140; 142; 143; 144; 145; 146; 149; 150; 151; 152; 153; 154; 155; 156; 158; 159; 160; 161; 162; 163; 165; 166; 167; 168; 169; 170; 171; 172; 173; 174; 175; 176; 180; 181; 182; 183; 184; 189; 192; 193; 194; 195; 197; 198; 199; 200; 207; 208; 210; 211; 212; 213; 214; 215; 218; 220; 222; 224; 225; 226; 229; 230; 231; 232; 233; 234; 238; 241; 242; 244; 245; 246; 247; 250; 256; 257; 258; 261; 262; 263; 264; 271; 359

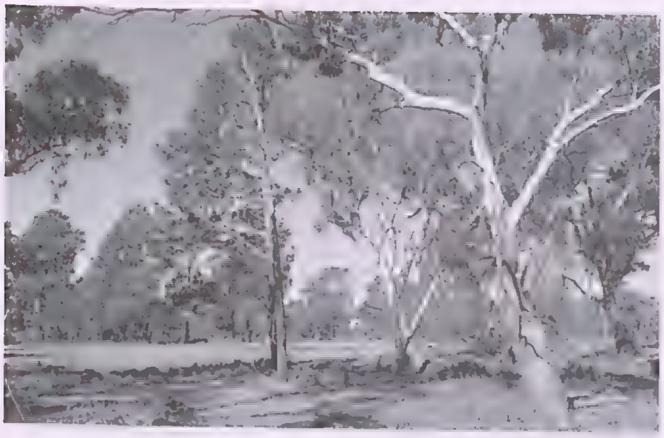

Fig. 10. The mainly cleared and endangered ID75 *Eucalyptus melliodora–Callitris glaucophylla* woodland on a sandy rise in Lake Urana Nature Reserve, (AGD66) 35°16'15.6" S 146°08'54.8" E. Photograph, Jaime Plaza, 9/4/2002.

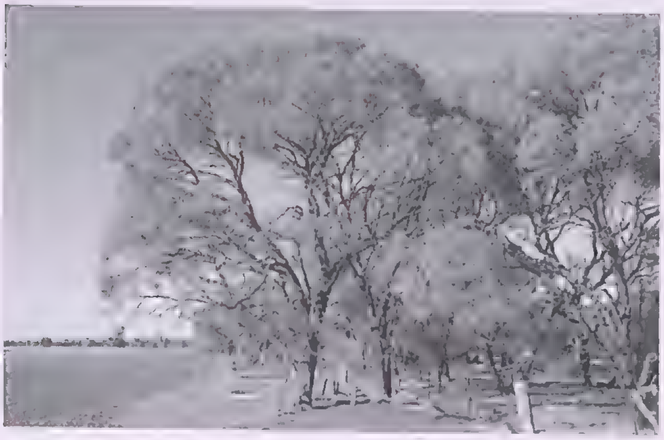

Fig. 11. ID77 *Acacia homalophylla* (Yarran) shrubland along the Barmedman – Wyalong Road in the NSW southern wheatbelt, (AGD66) 34° 08.360' S 147° 22.689' E. This is mainly cleared and endangered. Photograph, Jaime Plaza, 30/5/2007.

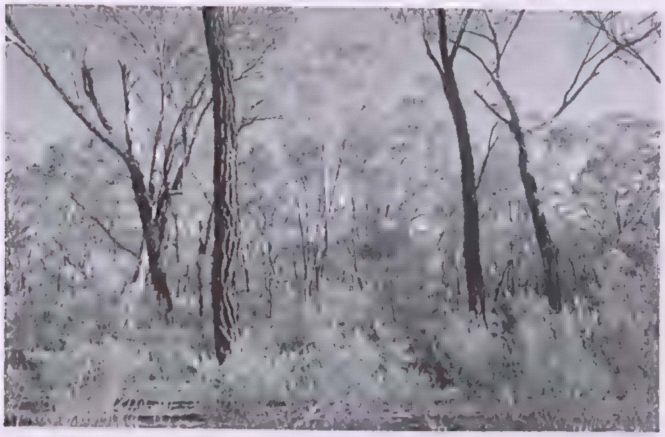

Fig. 12. D217: *Eucalyptus sideroxylon* (Mugga Ironbark) – *Eucalyptus microcarpa* (Inland Grey Box) shrubby woodland on a gravely rises in The Charcoal Tank Nature Reserve, (AGD66) 33°59'05.6" S 147°09'17.7" E. Photograph, Jaime Plaza, 19/4/02.

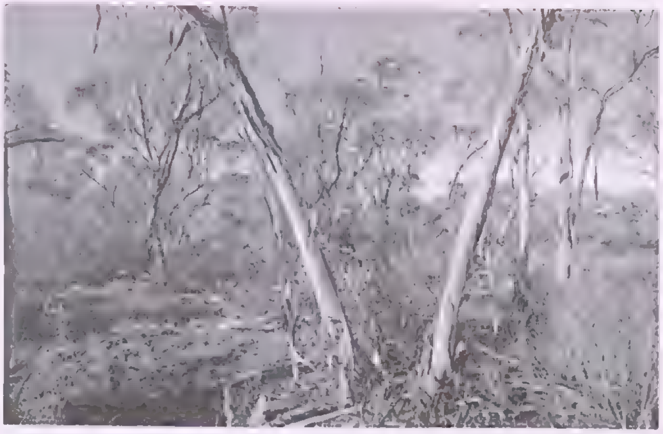

Fig. 13. Predominantly cleared ID355 *Eucalyptus behriana* (Bull Mallee) – *Eucalyptus socialis* (White Mallee) with *Acacia* spp., *Eremophila* spp. shrubs on red earth soils adjacent to the Wyalong – Barmedman Road and railway easement, (AGD66) 33° 56.355' S 147° 15.448' E. Photograph, Jaime Plaza, 31/5/2007.

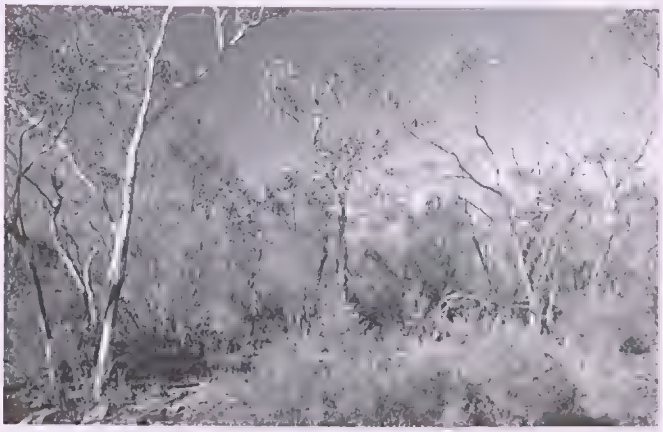

Fig. 14. The highly restricted and mainly cleared ID178 *Melaleuca uncinata* (Broombush) – *Eucalyptus dwyeri* (Dwyer's Red Gum) shrubland in The Charcoal Tank Nature Reserve, (AGD66) 33°59'08.0' S 147°09'07.4' E. Photograph, Jaime Plaza 19/4/02.

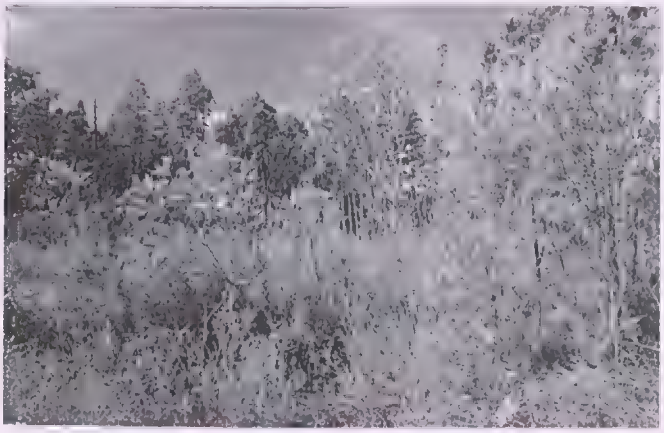

Fig. 15. ID292 *Allocasuarina diminuta* (She Oak) – *Calytrix tetragona* (Fringe Myrtle) shrubland on a rocky ridge in Goobang National Park, (AGD66) 32°55'41.8" S 148°23'46" E. Photograph, Jaime Plaza, 04/05/2005.

Plant communities in the Upper Slopes Sub-region

The Upper Slopes Sub-region contains hill landform patterns with some rocky north-south orientated ranges containing siliceous rocks such as sandstone, conglomerate, granite or rhyolite. Floodplains composed of alluvial soils adjoin larger rivers including the Murray, Murrumbidgee and Lachlan Rivers. Besides the limited areas of alluvial soils, most soils are derived from metamorphic and sedimentary rocks of the Lachlan Fold Belt. Colluvium occurs on footslopes of hills. The most widespread vegetation types in the Upper Slopes Sub-region are those in *Eucalyptus*-dominated grassy woodlands or shrubby open forests.

The plant communities occurring in the Upper Slopes Sub-region are listed in Folder 2 on the CD and are summarised below.

Eucalyptus camaldulensis (River Red Gum) tall open forest (ID79) (Figure 16) dominates the riparian zone of major streams but River Red Gum is replaced by *Eucalyptus blakelyi* (Blakely's Red Gum) at higher altitudes where the latter often overtops *Leptospermum* spp. – *Callistemon sieberi*-dominated shrublands that occupy the banks of streams (IDs 302 & 333) (Figure 17). *Casuarina cunninghamiana* (River Oak) dominated tall open forest (ID85) (Figure 18) occupies the riparian zone in the mid to upper reaches of major rivers and creeks extending into the South Eastern Highlands Bioregion (Southern Tablelands Botanical Division), mixing with River Red Gum in some locations.

On richer, deeper loam to clay soils derived from alluvium on river flats and on soils derived from fine-grained lithology on undulating hills, the ground cover in woodlands is dominated by a rich array of grass and forb species. However, most of the original extent of these grassy woodlands has disappeared through clearing and weed invasion (see discussion below). The two most widespread, but now mainly cleared, grassy woodlands are *Eucalyptus albens* (White Box) grassy woodland (mainly ID266) (Figure 19) and *Eucalyptus blakelyi* (Blakely's Red Gum) – *Eucalyptus melliodora* (Yellow Box) grassy woodland (mainly ID277) (Figure 20). Both occur across a wide range of substrates and soil types as documented in Prober (1996). Both are included in the Grassy Box–Gum woodland Endangered Ecological Community (EEC) listing under Federal and NSW threatened species laws. A Yellow Box dominated tall woodland of restricted extent, occurs in narrow valleys in the upper Murray River catchment (ID312). Similarly, *Eucalyptus bridgesiana* (Apple Box) tall grassy woodland occurs in valley flats throughout the Upper Slopes (ID283) (Figure 21) with a similar type occurring with *Eucalyptus nortonii* (Norton's Box) in valleys near Tumut (ID298). A restricted type of Apple Box dominated woodland occurs on basalt scree in the upper Murray River valley (ID314).

White Box shrubby or shrub-grass woodlands cover a large proportion of the steep hills in the Upper Slopes Sub-region, generally occurring on shallow soils. These include White

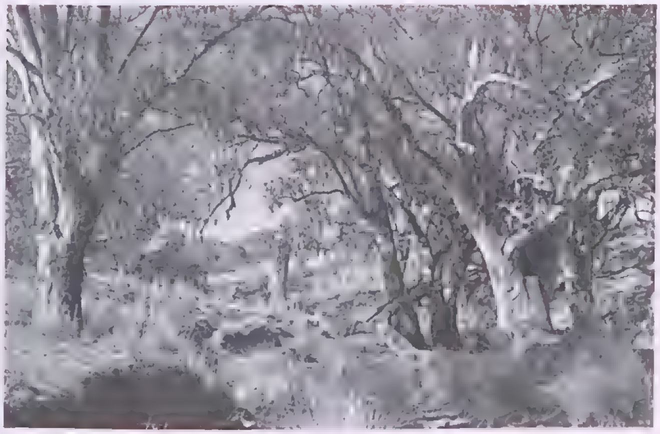

Fig. 16. ID79 Upper Slopes form of *Eucalyptus camaldulensis* (River Red Gum) riparian woodland with grassy ground cover, Canowindra-Goologong Rd, south-western slopes, (AGD66) 33°34'27" S 148°29'58" E. Photograph, Jaime Plaza, 11/10/02.

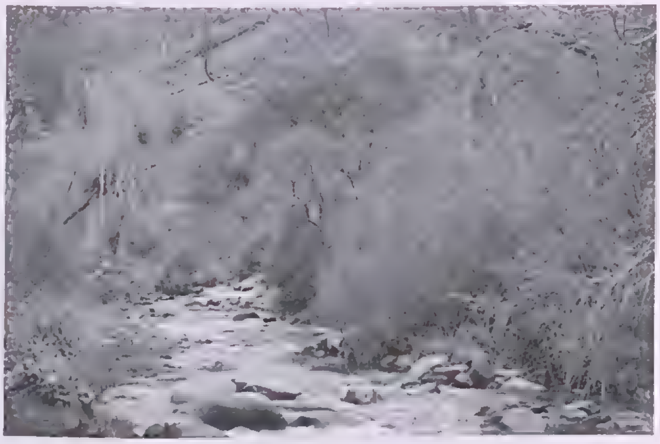

Fig. 17. ID302 Riparian shrubland with *Leptospermum obovatum Callistemon sieberi*, *Acacia kettlewelliae*, *Lomatia myrticoides* with Blackberry and Willow infestation along Tumbarumba Creek, south of Tumbarumba, (AGD66) 35° 52.946' S 148° 03.243' E. Photograph, Jaime Plaza, 5/5/2006.

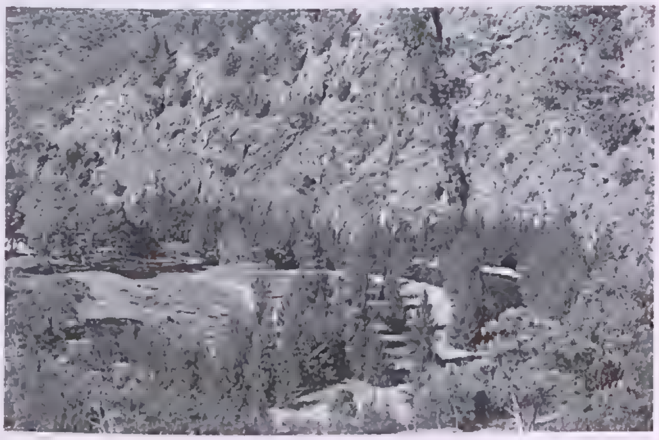

Fig. 18. ID85 *Casuarina cunninghamiana* (River Oak) tall woodland lining the Macquarie River in the Macquarie Gorge near Hill End, Photograph, Jaime Plaza, 9/5/2005.

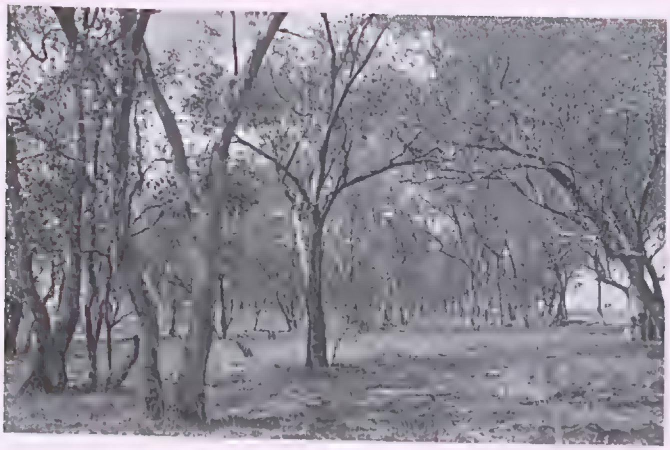

Fig. 19. ID266 *Eucalyptus albens* (White Box) grassy woodland, Quamby–Thuddungra TSR south of Grenfell, (AGD66) 34°09'28" S 148°08'39" E. Photograph, Jaime Plaza, 12/10/02.

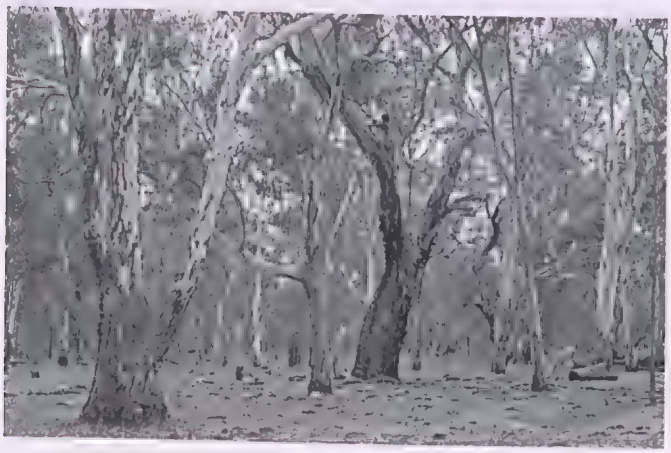

Fig. 20. ID277 *Eucalyptus melliodora* (Yellow Box) – *Eucalyptus blakelyi* (Blakely's Red Gum) tall woodland, on flats near Forbes (AGD66) 33°24'37" S 148°11'23" E. Photograph, Jaime Plaza, 10/10/02.

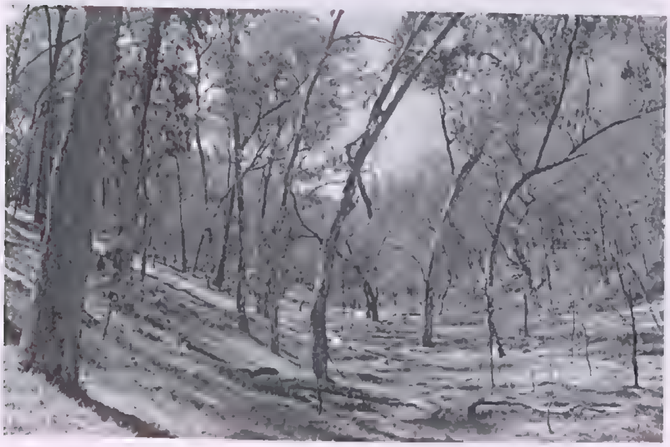

Fig. 21. ID283 *Eucalyptus bridgesiana* (Apple Box) – *Acacia dealbata* gully herbaceous woodland in Ellerslie Nature Reserve, 35°14'33" S 147°51'30" E. Photograph, Jaime Plaza, 20/10/02.

Box – White Cypress Pine – Inland Grey Box (ID267) woodland on loams in the western part of the sub-region and White Box – Blakely's Red Gum – White Cypress Pine woodland (ID346) on metamorphic hills in the Wagga Wagga region. To the east, shrubby White Box – *Eucalyptus polyanthemos* (Red Box) – *Eucalyptus macrorhyncha* (Red Stringybark) – Blakely's Red Gum woodland (ID268) occurs on shallow soils on steep hills. A similar White Box – Blakely's Red Gum – Red Box shrubby woodland that contains a high diversity of shrub species is restricted to the metamorphic hills around Albury (ID269) (Figure 22). Another shrubby woodland with White Box – Blakely's Red Gum – Red Stringybark and occasionally *Eucalyptus sideroxylon* (Mugga Ironbark) occurs on hills in the Tarcutta region (ID347). To the north, White Box – Black Cypress Pine – *Eucalyptus dealbata* (Tumbledown Gum) shrubby woodland (ID272) occurs on rocky ranges in central western NSW including in Nangar and Weddin Mountains National Parks. A poorly documented White Box – Tumbledown Gum – *Eucalyptus goniocalyx* (Long-leaved Box) low woodland occurs on steep slopes of shale or mudstone in the Macquarie River gorge (ID270), a White Box – Red Stringybark shrubby open forest (ID273) occurs on mudstone on very steep hills including Avisford Nature Reserve near Mudgee and a White Box – *Angophora floribunda* (Rough-barked Apple) open forest (ID274) occurs on fine – grained sedimentary substrates in valleys in the Mudgee region.

In addition to the widely distributed Blakely's Red Gum – Yellow Box woodland ID277 mentioned above, many other plant communities are dominated by Blakely's Red Gum. A shrub-grass community of Blakely's Red Gum – Apple Box – Yellow Box and occasionally Inland Grey Box (ID278) occurs in valleys in the central western slopes including Goobang National Park. A restricted community of Blakely's Red Gum with White Cypress Pine (ID279) occurs on colluvial soils on footslopes of hills and ranges such as the Weddin Mountains. In the region around Cootamundara, Blakely's Red Gum occurs with Long-leaved Box, Black Pine and a range of shrub species on hills composed of metamorphic substrates (ID280). This includes the naturally rare but otherwise weedy species *Acacia baileyana* (Cootamundra Wattle). On flatter terrain in the Tumut – Forbes – Cowra region, a woodland (ID282) occurs containing Blakely's Red Gum, White Box, Yellow Box and Black Cypress Pine with a grass-shrub ground cover (including the heath shrub *Lissanthe strigosa*) on clay loam soil on gently undulating hills. To the south of ID282 and restricted to the Murraguldrie region, a valley "swamp" Blakely's Red Gum – Red Stringybark open forest (ID284) is present that contains shrubs such as *Leptospermum continentale* and an abundance of *Juncus* and *Carex* in the ground cover. In the upper Lachlan catchment region Blakely's Red Gum occurs with *Eucalyptus polyanthemos* (Red Box) and *Callitris endlicheri* (Black Cypress Pine) (ID341). East of Cowra Blakely's Red Gum occurs with *Eucalyptus macrorhyncha* (Red Stringybark), *Eucalyptus goniocalyx* (Long-leaved Box) and *Brachychiton* *populneus* (Kurrajong) on granite hills between Reids Flat and Wyangala Dam (ID338) (Figure 23). In the far northern part of the NSW SWS Bioregion Blakely's Red Gum occurs on valley flats in association with *Angophora floribunda* (Rough-barked Apple) with a grass – forb ground cover (ID281). This community is more common in the Brigalow Belt South and Nandewar Bioregions to the north.

Eucalyptus polyanthemos (Red Box) is a dominant component of several Upper Slopes hill and valley plant communities. In one restricted community, it mixes with Blakely's Red Gum and White Box along drainage lines in Benambra National Park near Albury (ID286). Red Box also occurs in a small area with *Eucalyptus dwyeri* and *Xanthorrhoea glauca* subsp. *angustifolia* in Jingellic Nature Reserve in the upper Murray River region (ID315). The most widespread plant community with Red Box as a dominant species is ID287 (Figure 24) with other tree species including *Eucalyptus goniocalyx* (Long-leaved Box) and Red Stringybark. This open forest is distributed along much of the length of the Upper Slopes Sub-region. On ridges of hills east of Tumut, Red Box occurs with Red Stringybark and Norton's Box with a distinctive heath shrub understorey on a quartz-shale substrate (ID306). Red Box occurs with *Eucalyptus dealbata* (Tumbledown Gum), Red Stringybark and a diverse shrub understorey on acid volcanic substrate in the Wyangala Dam region, east of Cowra (ID345). In the far north of the NSWSWS Bioregion, Long-leaved Box and Red Box dominate the canopy of an open forest on hill slopes in the Mudgee region (ID326). Long-leaved Box and Black Cypress Pine are dominant trees in a low open forest occurring on shallow soils on granite in Woomargama National Park near Albury (ID288).

In the south-eastern corner of the NSWSWS Bioregion in the region from Albury to Tumut, *Eucalyptus nortonii* (Norton's Box) is one of the most common eucalypt species. There are several plant communities where it is the main tree species or a canopy co-dominant. Near to Albury in Benambra National Park and Tabletop Nature Reserve, Norton's Box occurs with Red Stringybark and *Acacia doratoxylon* (Currawang) to form low shrubby woodland on conglomerate and sandstone escarpments (ID293). To the east, Norton's Box mixes with Red Box and White Box to form an open forest with a distinct tussock grass (*Joycea pallida*) ground cover (ID294) on a granite substrate with examples of this in Woomargama National Park. As mentioned above, Norton's Box occurs with Apple Box in valleys near Tumut (ID298) and grows with Red Stringybark in an open forest on hills in this region (ID310). On shallow soils on the steep Minjary Range north of Tumut, Norton's Box occurs with Red Box, Red Stringybark with a dominance of *Stypandra glauca* (Nodding Flax Lily) in the ground cover (ID316) (Figure 25).

Eucalyptus dives (Broad-leaved Peppermint) and *Eucalyptus mannifera* subsp. *mannifera* (Brittle Gum) are common in a number of plant communities at high altitudes in the Upper Slopes Sub-region with both species being more abundant in the adjoining South Eastern Highlands Bioregion. Broad-leaved

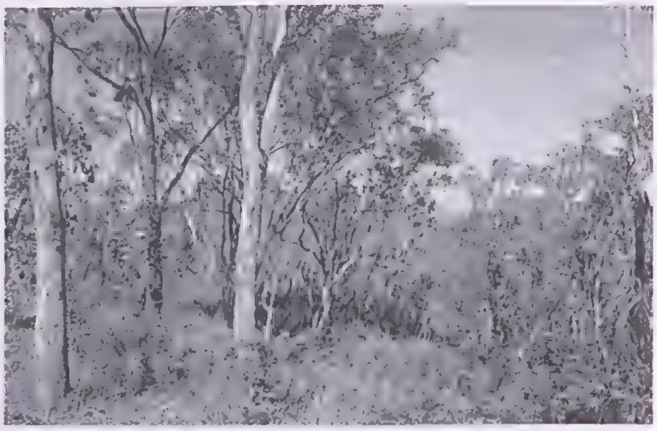

Fig. 22. ID269 *Eucalyptus albens* – *E. macrorhyncha* – *E. polyanthemos* – *E. blakelyi* shrub-rich woodland, Nail Can Hill, Albury, (AGD66) 36°03'00" S 146°54'07" E. Photograph, Jaime Plaza, 18/10/02.

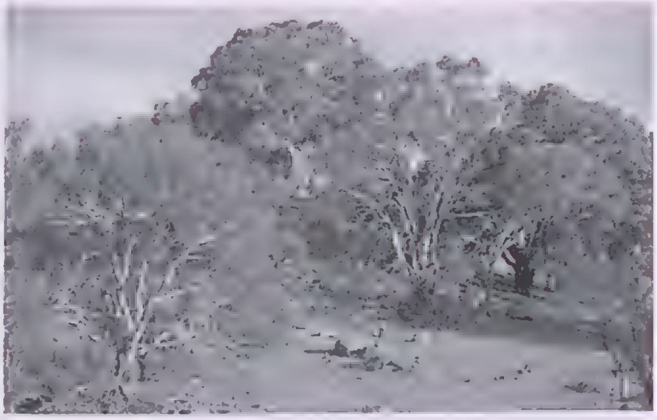

Fig. 23. ID338 *Eucalyptus macrorhyncha* (Red Stringybark) – *Eucalyptus blakelyi* (Blakely's Red Gum) – *Eucalyptus goniocalyx* (Long-leaved Box) woodland on granite hills with an exotic species ground cover on the Rugby to Crookwell road west of the Lachlan River, (AGD66) 34° 24.632' S 149° 03.077' E. Photograph, Jaime Plaza, 29/5/2007.

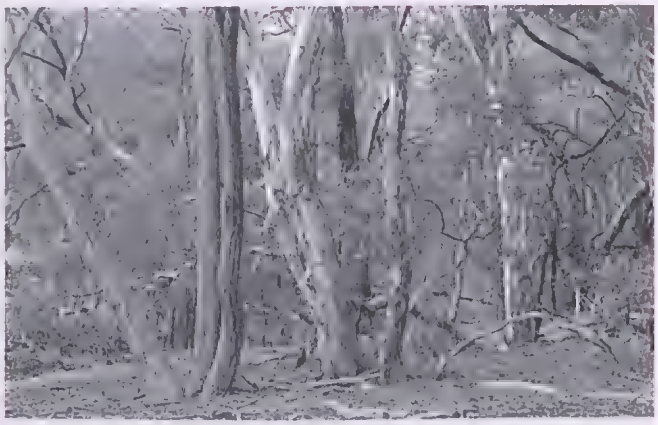

Fig. 24. ID287 *Eucalyptus polyanthemos* (Red Box) – *Eucalyptus goniocalyx* (Long-leaved Box) – *Eucalyptus macrorhyncha* (Red Stringybark) open forest on brown clay derived from phyllite, 10 km south-east of Rye Park, (AGD66) 34° 33.418' S 148° 59.025' E. Photograph, Jaime Plaza, 29/5/2007.

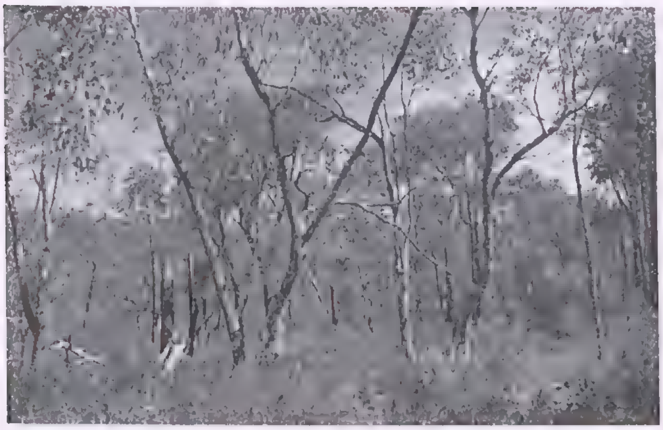

Fig. 25. ID316 *Eucalyptus nortonii – E. macrorhyncha – E. polyanthemos – Stypandra glauca* low woodland on hillcrests in Minjary National Park, (AGD66) 35°14'31" S 148°07'34" E. Photograph, Jaime Plaza, 16/10/02.

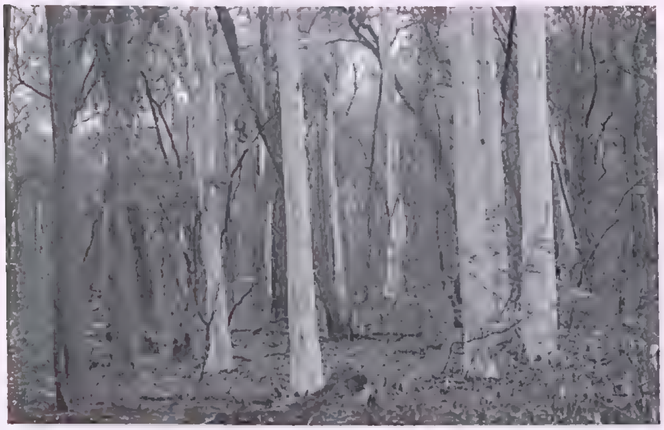

Fig. 26. ID296 *Eucalyptus mannifera* (Brittle Gum) – *Eucalyptus dives* (Broad-leaved Peppermint) – *Eucalyptus macrorhyncha* (Red Stringybark) open forest on quartzite ridges in Woomargama National Park, (AGD66) 35° 54.773' S 147° 18.669' E. Photograph, Jaime Plaza, 2/5/2006.

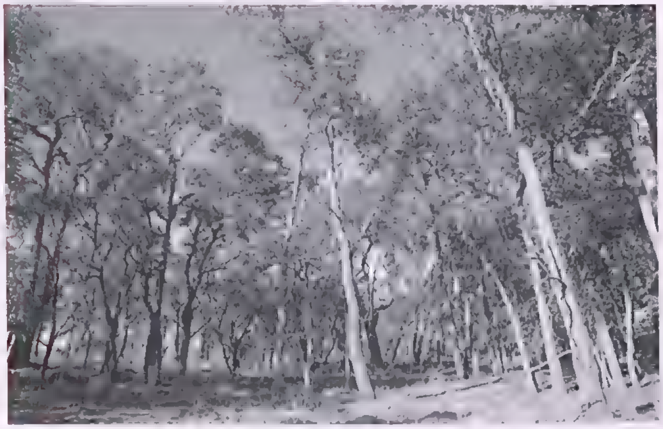

Fig. 27. ID344 *Eucalyptus cinerea* (Argyle Apple) with *Eucalyptus mannifera* (Brittle Gum) and *Eucalyptus goniocalyx* (Long-leaved Box) open forest in a drainage line on hills in the Blackney's Road north of Yass. This community is mainly cleared and is poor reserved. (AGD66) 34° 41.899' S 149° 00.013' E. Photograph, Jaime Plaza, 29/5/2007.

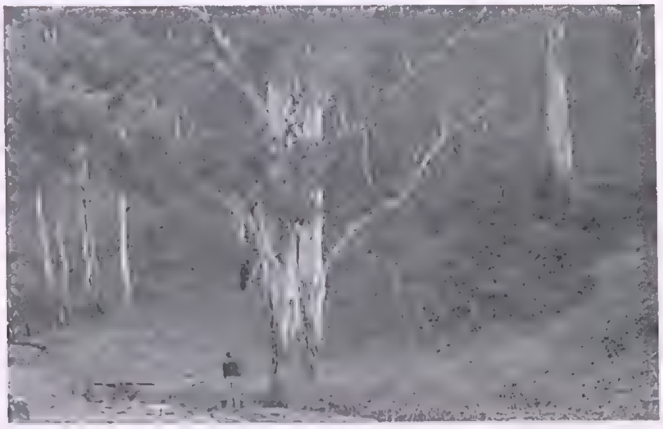

Fig. 28. ID299 *Eucalyptus viminalis* (Ribbon Gum) tall open forest along a creek infested with Blackberry, east of Tumut, (AGD66) 35° 23.443' S 148° 13.920' E. Photograph, Jaime Plaza, 30/4/2006.

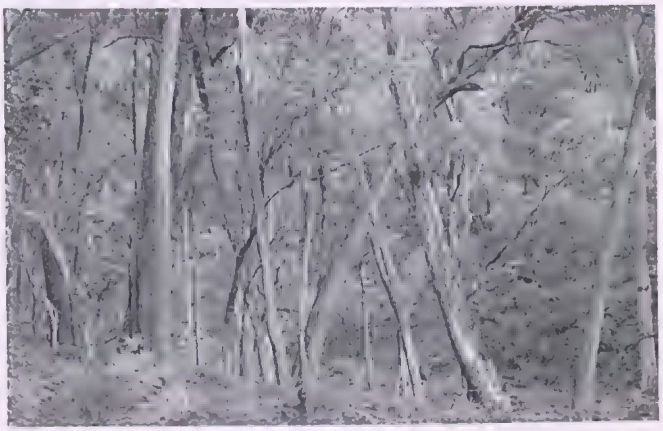

Fig. 29. . ID307 *Eucalyptus bicostata* (Eurabbie) and *Eucalyptus robertsonii* (Robertson's Peppermint) very tall open forest on protected slopes in Woomargama National Park has limited extent but is well reserved, (AGD66) 35° 55.625' S 147° 17.891' E. Photograph, Jaime Plaza, 2/5/2006.

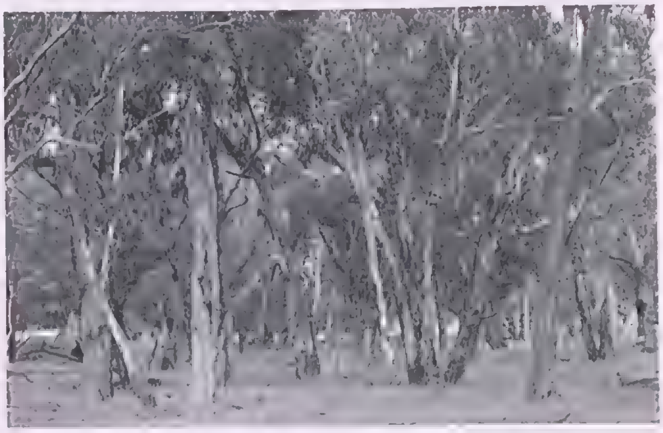

Fig. 30. Extensively cleared ID304 *Eucalyptus rubida* (Candlebark) – *Eucalyptus robertsonii* (Robertson's Peppermint) tall open forest on yellow podsol soil on granite, Hume TSR near Mundaroo, (AGD66) 35° 50.756' S 147° 49.637' E. Photographer, Jaime Plaza, 1/5/2006.

Peppermint mixes with Norton's Box and Red Stringybark in an open forest (ID297) that covers extensive areas of ridges and upper hill-slopes in the Tumut to Albury region. In this same region, Broad-leaved Peppermint also occurs in an open forest in association with Brittle Gum and box eucalypt species such as Norton's Box or Long-leaved Box on hills composed of a range of substrates (ID296) (Figure 26). A variant of ID296 that contains a dense understorey of shrub species such as *Mirbelia oxyloboides* and *Acacia melanoxylon* is restricted to Woomargama National Park (ID313). On hills composed of metamorphic and granodiorite substrates in the Tumbarumba region, Broad-leaved Peppermint grows with *Eucalyptus bridgesiana* (Apple Box) and Red Stringybark with a shrubby understorey that includes *Bursaria spinosa* and *Cassinia longifolia* (ID305). A separate Brittle Gum – Broad-leaved Peppermint open forest community (ID351), containing a Fabaceae-rich shrub cover including *Daviesea leptophylla*, *Dillwynia sericea* and *Acacia dunnii*, occurs on poor soils north of Yass on the upper limit of the NSWSWS Bioregion extending and principally occurring in the South Eastern Highlands Bioregion. ID351 often grades into a restricted riparian or lower footslopes open forest dominated by *Eucalyptus cinerea* (Argyle Apple) (ID344) (Figure 27). This community is restricted to creeklines and flats east of Rye Park and is more extensive in the South Eastern Highlands Bioregion.

Very tall shrub-fern open forests occupy high rainfall areas in the south-eastern corner of the Upper Slopes Sub-region from Tumut to Woomargama National Park and bordering the western boundary of Kosciuszko National Park in the South Eastern Highland Bioregion. These forests are similar to tablelands "wet" forests in their structure and species composition. They include the widespread *Eucalyptus robertsonii* (Robertson's Peppermint) – Broad-leaved Peppermint – Nortons Box – *Pterydium esculentum* (Bracken Fern) shrub-fern open forest (ID295), Riparian *Eucalyptus viminalis* (Ribbon Gum) tall forest (ID299) (Figure 28), montane plateau *Eucalyptus viminalis* (Ribbon Gum) – Robertson's Peppermint tall fern forest (ID300) and *Eucalyptus bicostata* (Eurabbie) very tall open forest (ID307) (Figure 29) in gullies and on protected slopes. These forests are well sampled in Woomargama National Park and other reserves in the Tumbarumba to Tumut region.

Tall woodlands containing *Eucalyptus rubida* (Candlebark) are rare in the NSWSWS Bioregion but are common in the adjoining South Eastern Highlands Bioregion. A Candlebark – Apple Box – *Eucalyptus robertsonii* (Robertson's Peppermint) dominated tall woodland occurs yellow soils derived from granite west of Tumbarumba (ID304) (Figure 30). A different Candlebark woodland occurs on river flats and along creeks near Rye Park, north of Yass where Candlebark grows with *Eucalyptus blakelyi* (Blakely's Red Gum) and Long-leaved Box (ID350) with a grassy ground cover. Both of these Candlebark communities are extensively cleared, heavily grazed and are highly threatened.

Although ironbark-dominated woodlands cover less area in the NSWSWS Bioregion compared to the Brigalow Belt South Bioregion to the north, 10 ironbark-dominated woodlands have been classified. Two (ID243 and ID217) are mainly distributed in the Lower Slopes Sub-region and have been mentioned above. Eight communities occur in the Upper Slopes Sub-region. Six of these (IDs 289, 318, 330, 342, 343 and 358) are dominated by Mugga Ironbark (*Eucalyptus sideroxylon*) and two (IDs 328, 329) are dominated by Red Ironbark (*Eucalyptus fibrosa*).

Most ironbark–dominated woodland or forest occurs on hillcrests or hillslopes. ID289 is a widely distributed open forest that occurs on hills at higher altitudes. It contains *Eucalyptus sideroxylon* (Mugga Ironbark) and *Eucalyptus rossii* (Scribbly Gum) often with *Eucalyptus polyanthemos* (Red Box) or *Eucalyptus goniocalyx* (Long-leaved Box). Elsewhere, Mugga Ironbark mixes with a number of other *Eucalyptus* species including *Eucalyptus albens* (White Box) on hills in the Young to Cowra regions (ID342) (Figure 31). A similar community with Mugga Ironbark, Blakley's Red Gum, *Callitris endlicheri* (Black Cypress Pine) and Red Stringybark (ID330) occurs on the central western slopes including in Nangar, Weddin Mountains and Goobang National Parks. To the south in the Tarcutta – Gundagai region, a Mugga Ironbark – Red Box – Red Stringybark with occasional Inland Grey Box woodland occurs on mainly metamorphic substrates (ID343). Mugga Ironbark co-dominates with *Eucalyptus dealbata* (Tumbledown Gum), Black Cypress Pine with a shrubby understorey on acid volcanic and other silica-rich substrates at lower altitudes in the Upper Slopes Sub-region (ID318). On hills in the Wellington to Mudgee region in the north of the sub-region, Mugga Ironbark occurs with Red Box and White Box on fine-grained sedimentary substrates (ID358).

Eucalyptus fibrosa (Red Ironbark) occurs with *Callitris endlicheri* (Black Cypress Pine) in a shrub-rich woodland (ID328) on acidic volcanic and granite ranges in the ranges near Peak Hill including in Goobang National Park. A similar shrubby woodland community in which Red Ironbark mixes with *Eucalyptus macrorhyncha* (Red Stringybark), *Eucalyptus dealbata* (Tumbledown Gum) and *Acacia doratoxylon* (Currawang) occurs on shallow sandy soils derived from sandstone in the Goobang National Park region (ID329) (Figure 32). Red Ironbark is common as a dominant tree in other plant communities the Pilliga Scrub in the Brigalow Belt South Bioregion to the north.

A number of *Eucalyptus dealbata* (Tumbledown Gum) dominated woodlands occur in the NSWSWS Bioregion on rocky hills composed of acid volcanic, granite, sandstone or conglomerate substrates. Tumbledown Gum occurs with White Cypress Pine on clay soils on hills south of Wagga Wagga (ID319), with Black Cypress Pine and Red Stringybark on rocky sandstone outcrops in the central section of the Upper Slopes Sub-region in locations such as Nangar and Conimbla National Parks and Mount Arthur

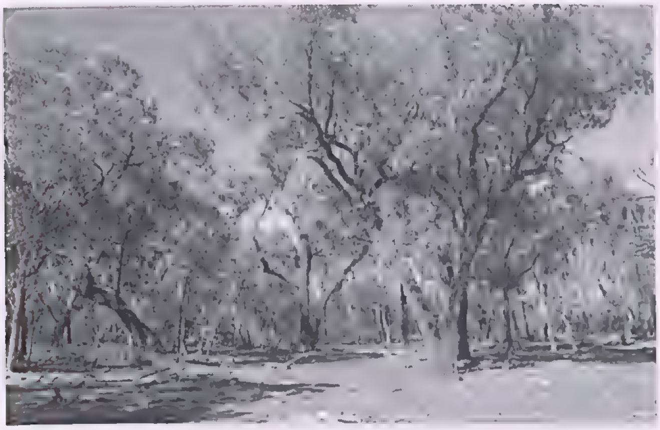

Fig. 31. ID342 *Eucalyptus sideroxylon* (Mugga Ironbark) – *E. polyanthemos* (Red Box) woodland in Ilunie Nature Reserve south east of Koorawatha, (AGD66) 34° 09.806' S 148° 35.671' E. Photograph, John Benson, 13/2/2007.

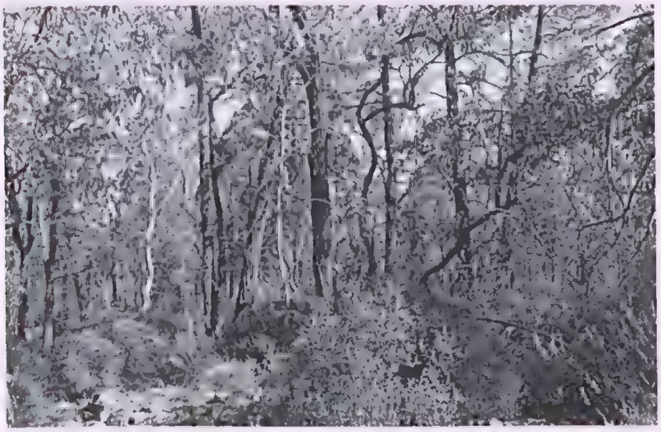

Fig. 32. ID329 *Eucalyptus fibrosa* (Red ironbark) – *E. dwyeri* – *Callitris endlicheri* low open forest on acidic rocks in the Hervey Range in Goobang National Park, (AGD66) 32°55' 21.2" S 148°22' 37.7" E. Photograph, Jaime Plaza, 04/05/2005.

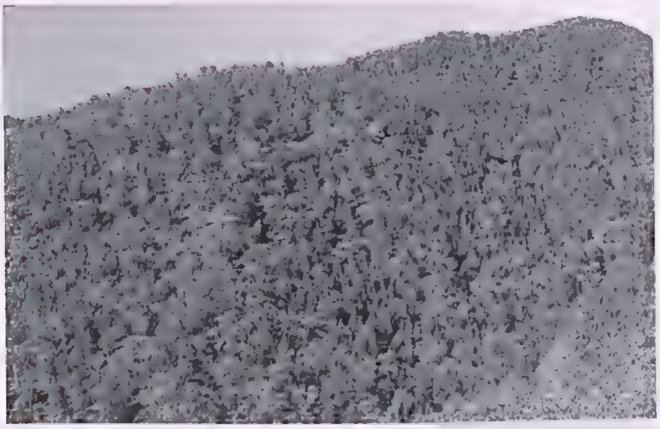

Fig. 33. ID332 *Eucalyptus dealbata* (Tumbledown Gum) – *Callitris endlicheri* (Black Cypress Pine) – *E. macrorhyncha* (Red Stringybark) low open forest in the Mt Arthur Reserve near Wellington, (AGD66) 32°33' 5.4" S 148°54' 34" E. Photograph, Jaime Plaza, 08/05/2005.

near Wellington (ID332) (Figure 33), and with Black Cypress Pine, Red Stringybark, *Eucalyptus polyanthemos* (Red Box) and *Allocasuarina verticellata* (Drooping She-oak) on granite near Wyangala Dam east of Cowra (ID339). *Eucalyptus dealbata* is also a major component of the *Eucalyptus sideroxylon* (Mugga Ironbark) open forest (ID318) that occurs on outcrops of rhyolite and other acidic substrates. Tumbledown Gum is a major component of plant communities on acid volcanic outcrops in the Brigalow Belt South and Nandewar Bioregion to the north of the NSWSWS Bioregion.

Eucalyptus macrorhyncha (Red Stringybark) is the most ubiquitous *Eucalyptus* species in the higher altitude eastern parts of the Upper Slopes Sub-region. It is present in most of the woodlands and open forests cited above but there are some areas where it is so dominant that it forms Red Stringybark communities. Red Stringybark is also often co-dominant with *Eucalyptus rossii* (Scribbly Gum). These communities occur along the length of the Upper Slopes Sub-region.

In the south of the bioregion a Red Stringybark – Red Box – Long-leaved Box – Scribbly Gum grassy open forest (ID290) is widespread on clay-loam soils on hillslopes from south of Wagga Wagga to the upper Murray River. A Scribbly Gum-dominated open forest with Black Cypress Pine – Mugga Ironbark and *Brachyloma daphnoides* low shrub layer (ID291) occurs in the Livingston National Park region south of Wagga Wagga. Further east in the upper Murray River region, small patches of Red Stringybark with *Eucalyptus dives* (Broad-leaved Stringybark) and a heath shrub understorey occur on shallow quartz-rich soils (ID311). To the north, a shrubby Red Stringybark low open forest occurs on granite hills in the Boorowa - Wyangala Dam region (ID340) and to the east of this, in the upper Lachlan and Murrumbidgee catchments, Red Stringybark occurs with Blakley's Red Gum on hills composed of red clay derived from metamorphic substrates (ID352). In the Boorowa to Young region, a restricted open forest dominated by Scribbly Gum with Red Stringybark with shrub species including *Daviesia latifolia* occurs on sandy loam soils on broad ridges (ID353). Further north, between the towns of Cowra and Orange, Red Stringybark occurs with Long-leaved Box and Black Cypress Pine on rocky sandstone hills (ID321). In this same region, a Scribbly Gum open forest occurs with Red Stringybark and Black Cypress Pine on hills composed of siliceous substrates, including granite (ID322). To the west, a Scribbly Gum dominated open forest occurs with Black Cypress Pine and *Eucalyptus fibrosa* (Red Ironbark) on sandy soils on ridges in the Hervey and Currumbenya Ranges including in Goobang National Park (ID327). In this same region, Red Stringybark occurs with Red Ironbark, Mugga Ironbark and Black Cypress Pine comprising a woodland mainly on sandstone substrates (ID331). In the same region Red Stringybark occurs with Long-leaved Box and Black Cypress Pine on rhyolite ridges (ID354) sometimes with *Triodia scariosa* (Porcupine Grass) in the ground cover. In the Mudgee region, in north-east corner of the NSWSWS

Bioregion, Red Stringybark dominated (ID323) (Figure 34), *Eucalyptus agglomerata* (Blue-leaved Stringybark) dominated and Scribbly gum dominated (ID324) shrub-tussock grass open forests occur on steep hills, including in the Avisford Nature Reserve. A widespread Scribbly Gum - Red Stringybark open forest (ID349) (Figure 35), with a sparse shrub layer and a mid-dense tussock grass ground cover, occurs from Yass to Orange in the South Eastern Highlands sub-region extending into the higher altitudes of the Upper Slopes Sub-region. Closely allied to this is a Red Stringybark – Long-leaved Box – tussock grass open forest that occupies more protected hillslopes (ID348).

Eucalyptus dwyeri (Dwyer's Red Gum) is probably the most common "hill red gum" in the NSWSWS Bioregion. The ubiquitous and broadly classified *Eucalyptus dwyeri* (Dwyer's Red Gum) – *Acacia doratoxylon* (Currawang) – *Callitris endlicheri* (Black Cypress Pine) low woodland (ID186) (Figure 36) occurs on skeletal lithosol soils on the crests of most of the rocky hills in the bioregion. While the most common rock type is sandstone it also occurs on granite and conglomerate outcrops. While the floristic composition of ID186 ranges a suite of species remains consistent. ID186 grades into areas dominated by *Callitris endlicheri* (Black Cypress Pine) low open forest (ID309) and *Acacia doratoxylon* (Currawang) (ID317) (Figure 37) low woodland. These last two communities also occur on rocky ranges composed of siliceous substrates such as sandstone, granite and adamellite. The best sample of Black Cypress Pine low open forest in the NSWSWS Bioregion (ID317) is on adamellite in Mudjarn Nature Reserve.

As mentioned above, riparian, myrtaceous shrublands (ID302 & ID333) dominated by *Leptospermum* spp. or *Callistemon sieberi* grow on the banks of streams at higher altitudes in the Upper Slopes Sub-region. At lower elevations, a shrubland dominated by *Allocasuarina diminuta* (she oak) – *Calytrix tetragona* (Five Fringe Myrtle) (ID292) (Figure 15) occurs in small patches on rocky (mainly sandstone) hills including in a number of conservation reserves.

One of the most floristically and structurally distinct plant communities in the NSWSWS Bioregion is a very tall shrubland growing on serpentinite outcrops on ridges and steep slopes between the towns of Tumut and Coolac (ID301) (Figure 38). This is dominated by the very tall shrub *Allocasuarina verticillata* (Drooping She-oak), the shrub *Ricinocarpos bowmanii*, the grasstree *Xanthorrhoea glauca* subsp. *angustifolia* and wattles such as *Acacia implexa* and *Acacia decora*. The trees *Eucalyptus nortonii* (Norton's Box) and *Eucalyptus albens* (White Box) are scattered throughout. The regionally depleted tall shrub *Banksia marginata* (Silver Banksia) grows in some gullies and lower slopes on the serpentinite with Drooping She-oak under a woodland canopy of *Eucalyptus bridgesiana* (Apple Box), *Eucalyptus mellidora* (Yellow Box) and *Eucalyptus nortonii* (Norton's Box) (ID337).

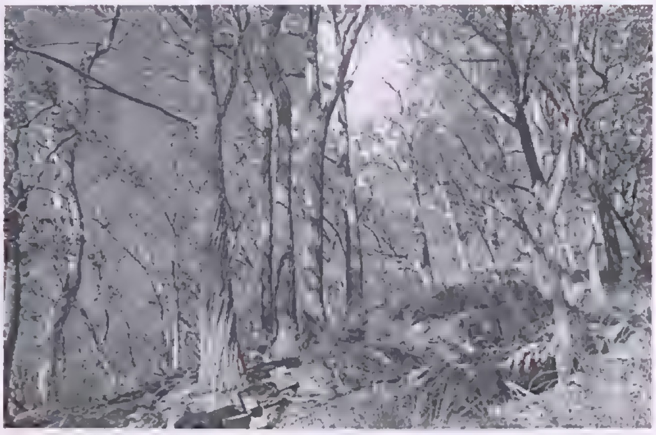

Fig. 34. ID323 *Eucalyptus macrorhyncha* (Red Stringybark) open forest on ridges in Avisford Nature Reserve near Mudgee, (AGD66) 32°38' 5.2" S 149°33' 43.5" E. Photograph, Jaime Plaza, 09/05/2005.

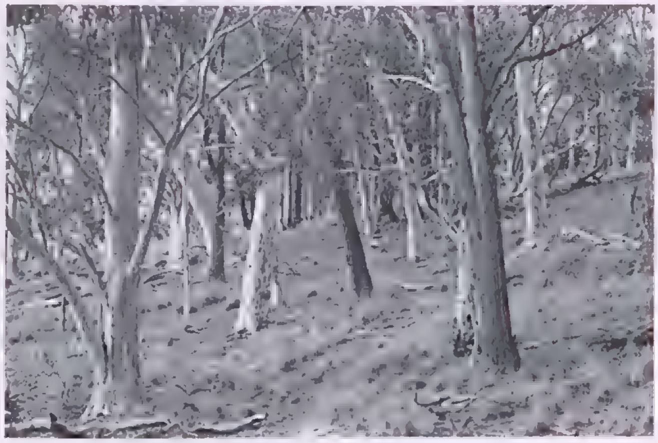

Fig. 35. ID349 *Eucalyptus macrorhyncha* (Red Stringybark) – *Eucalyptus rossii* (Scribbly Gum) open forest with *Joycea pallida* tussock grass ground cover on brown clay derived from phyllite east of Rye Park, (AGD66) 34° 33.149' S 148° 59.400' E. Photograph, Jaime Plaza, 29/5/2007.

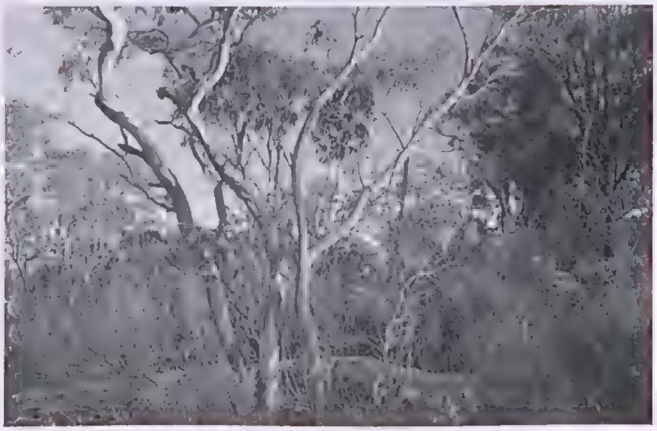

Fig. 36. ID186 *Eucalyptus dwyeri* Dwyer's Red Gum with *Callitris endlicheri*, and the shrubs *Calytrix tetragona* and *Acacia verniciflua* on rocky outcrops in Woomargama National Park, (AGD66) 35° 51.792' S 147° 23.501' E. Photograph, Jaime Plaza, 2/5/2006.

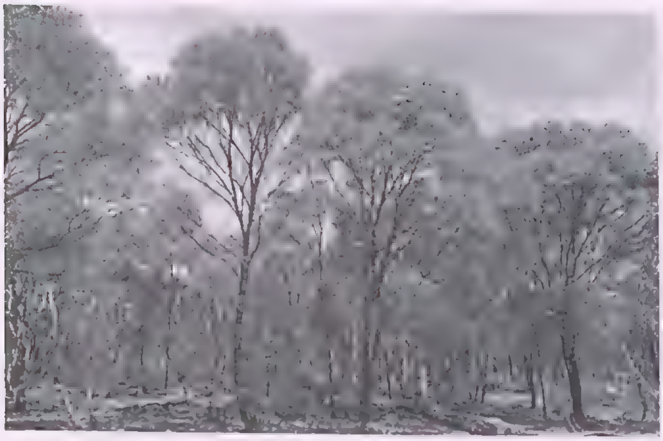

Fig. 37. ID317 *Acacia doratoxylon* very tall shrubland on sandstone ridge in Nangar National Park, (AGD66) 33°25'30" S 148°31'47" E. Photograph, Jaime Plaza, 10/10/02.

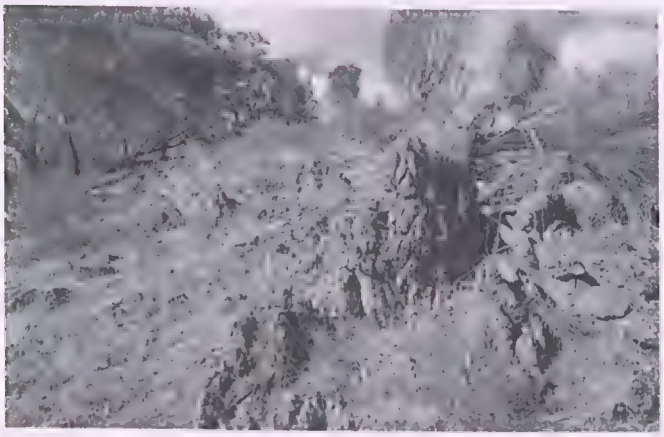

Fig. 38. D301 *Allocasuarina verticillata – Eucalyptus nortonii – Xanthorrhoea glauca* subsp. *angustifolia – Ricinocarpus bowmannii* tall shrubland on Coolac serpentinite on the Honeysuckle Range near Brungle, (AGD66) 35° 07.734' S 148° 17.996' E. Photograph, Jaime Plaza, 7/5/2006.

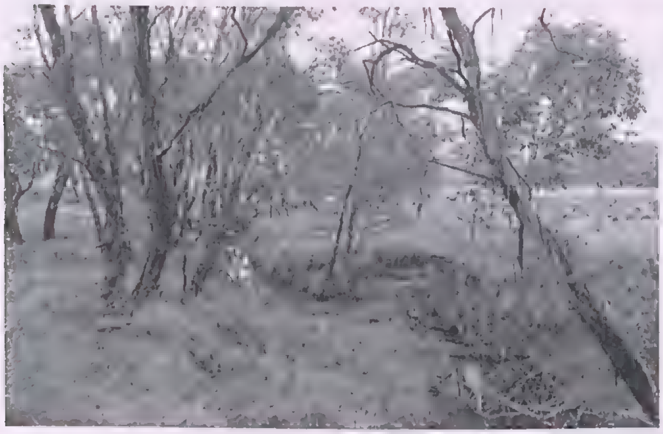

Fig. 39. ID285 *Eucalyptus camphora* subsp. *humeana* (Broad-leaved Sally) bordering Tarcutta Swamp near Batlow, NSW South East Highlands Bioregion (AGD66) 35° 40.470' S 148° 02.096' E. Photograph, Jaime Plaza, 1/5/2006.

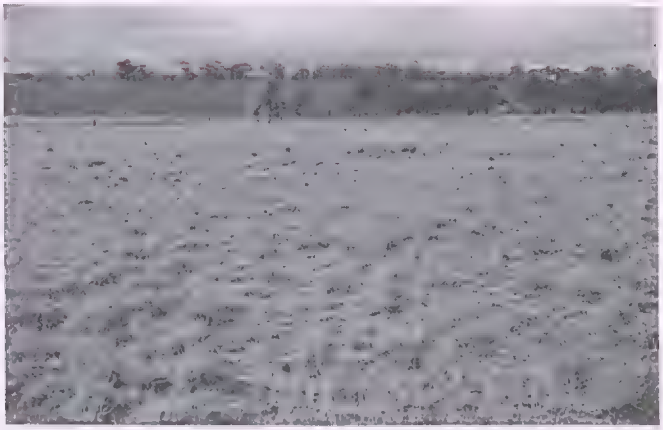

Fig. 40. ID320 *Themeda australis* Kangaroo Grass – *Bothroichloa macra* (Redleg Grass) forb-rich grassland on Tarengo Travelling Stock Reserve near Boorowa, (AGD66) 34° 28.380' S 148° 39.966' E. Photograph, Jaime Plaza, 29/5/2007.

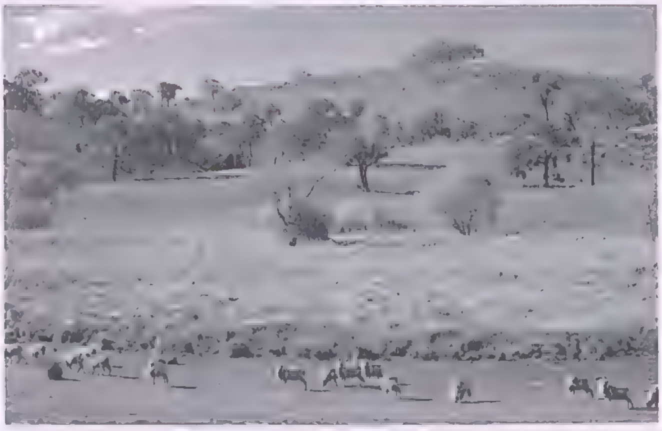

Fig. 41. ID335 *Poa labillardierei – Phragmites australis – Typha – Juncus* swamp on alluvial organic soil in a valley near Walla Walla east of Rye Park in the upper Lachlan River catchment, (AGD66) 34 32 833 S 148 57.007 E. Photograph, Jaime Plaza, 29/5/2007.

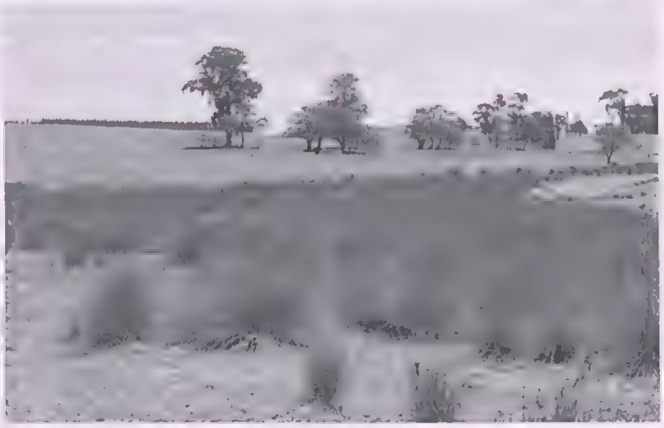

Fig. 42. ID335 Disturbed saline watercourse dominated by the weed *Juncus acutus* subsp. *acutus* with *Poa* and *Cynodon* on Salt Water Creek on the Boorowa-Rugby road NSW SW Slopes, (AGD66) 34 23.977 148 45.407. Photograph, John Benson, 13/2/2007.

The tall shrubs *Kunzea ericoides*, *Kunzea parvifolia* and *Leptospermum continentale* form a shrubland on cleared granite or acid volcanic substrates, for example, in Red Stringybark – Tumbledown Gum – Black Cypress Pine shrubby open forest (ID340) in the Wyangala Dam region. In the north of the NSWSWS Bioregion, *Prostanthera nivea* var. *nivea*, *Beyeria viscosa*, *Westringia eremicola* and *Acacia vestita* form a shrubland with an overstorey of *Eucalyptus dealbata* (Tumbledown Gum) (ID357) on conglomerate outcrops in creek gorges and on the lower hill-slopes of the Catombal Range near Wellington.

Valley flat or riparian frost hollow low grassy woodlands, that are common in the cool climes of the NSW tablelands, are rare in the NSWSWS Bioregion. Small areas of *Eucalyptus stellulata* (Black Sally) low grassy woodland occur along creeks west and south of Tumbarumba (ID303). Also, *Eucalyptus camphora* subsp. *humeana* (Broad-leaved Sally) low sedge-grass woodland (ID285) (Figure 39) occurs along creeks, surrounding swamps and on moist flats from Tumut to Woomargama National Park. This community may include shrubs such as *Acacia kettlewelliae* and *Leptospermum continentale*.

Native grasslands are much rarer in the NSWSWS Bioregion than in the NSW Western Plains to the west or in the South Eastern Highlands Bioregion to the east. Small areas of *Themeda – Bothriochloa* dominated native grasslands occur on travelling stock reserves near Boorowa (ID320) (Figure 40) with similar grassland more common in the Canberra region on the tablelands 120 km to the south-east. Areas of *Aristida – Austrodanthonia – Austrostipa* derived native grassland (i.e. where trees have been removed from previous woodlands) remain in the central – north of the NSW SWS Bioregion (ID250). *Bothriochloa macra* (Red-leg Grass) and species of *Austrostipa* (spear grass) are common on some cleared hills in the Albury to Holbrook region. However, overall, most areas have been cleared converted to exotic pasture. Derived native grassland in the NSWSWS Bioregion is comparatively rare compared to its abundance in the NSW Western Plains and in the Brigalow Belt South and Nandewar Bioregions that comprise the NSW north western slopes (Lodge & Whalley 1989).

Wetlands are relatively limited in extent in the Upper Slopes Sub-region compared to the floodplains of western NSW. Hundreds of small Rush – Sedge – *Phragmites australis* (Common Reed) wetlands occur on the floodplains of the upper Murrumbidgee and Murray Rivers (ID336). A restricted ephemeral wetland (ID360) occurs in gilgai depressions on grey clays from Albury to Holbrook and to the west extending into the Lower Slopes Sub-region. Swamps occur along some smaller creeks, where sediment and organic soils have accumulated on valley floors. These are dominated by *Poa labillardierei* (Snow Grass), *Carex appressa* and species of *Juncus* (ID335) (Figure 41). Most of these swamps have been degraded by drainage, clearing and grazing. In highly

Table 6. Number and different types of protected areas in the NSW South-western Slopes Bioregion and for all of NSW, March 2008.

Notes. The figures excludes 163,200 ha of marine parks in coastal waters of NSW, 10,877 ha of land in 10 Crown Reserves managed by DECC in eastern NSW and about 10,000 ha of Kosciuszko National Park from the statistics on the NSWSWS Bioregion. DECC Acquired lands are allocated to reserve types based on advice from DECC Parks and Wildlife Division. The Brigalow Belt South Bioregion Forest Assessment "Community Conservation Areas" Zones 1–3 (CCA) are allocated to National Park, Aboriginal Area or Nature Reserve categories. Data sources are: DECC Estates and Acquired Lands GIS layer 7.4 March 2008; DECC GIS on Voluntary Conservation Agreements, March 2008; NSW State Forests Flora Reserves GIS layer 2008; Property Agreement data from the former NSW Department of Infrastructure, Planning and Natural Resources PANet database and GIS layers, December 2003 – PAs in perpetuity were selected using shape files coded as being remnant vegetation (i.e. excluding cleared land being re-vegetated). *Assumes that VCAs are being made over the 28,906 ha 'Nanya Station' owned by Ballarat University and the 64,653 ha 'Scotia Sanctuary' owned by the Australian Wildlife Conservancy. Calculations were undertaken in ArcView Version 3.3 (ESRI Inc. 1992–2002) in Lamberts projection and AGD66.

Protected Area Type	**No. in NSW**	**Area (ha) in NSW**	**% of NSW**	**No. in NSW SWS**	**Area (ha) in NSW SWS**	**% of NSW SWS**
Aboriginal Areas	19	33,594	0.042	1	61	0.001
Historic Sites	15	3,219	0.004	3	43	0.001
Karst Conservation Reserves	4	4,575	0.006	1	814	0.010
National Parks	212	5,211,889	6.520	9	98,796	1.206
Nature Reserves	400	891,913	1.116	30	34,938	0.426
State Conservation Areas	130	633,913	0.793	5	10,789	0.132
Total all DEC reserves	780	6,779,104	8.480	49	145,441	1.775
Flora Reserves	88	30,177	0.038	7	4,435	0.054
Total all public reserves	**868**	**6,809,280**	**8.518**	**56**	**149,876**	**1.830**
Secure PAs (NVC Act)	55	5,542	0.007	35	2,106	0.026
VCAs (NPW Act)*	229	114,592	0.143	13	936	0.011
Bush Heritage Reserves	5	2,396	0.003	1	432	0.005
Total non-public protected areas	**289**	**122,531**	**0.153**	**49**	**3,474**	**0.042**
Total for all protected areas	***1,157***	***6,931,811***	***8.67***	***105***	***153,350***	***1.87***

saline catchments, such as the Boorowa River in the Lachlan River catchment, the invasive exotic Rush *Juncus acutus* subsp. *acutus* (Figure 42) and the introduced perennial pasture grass *Phalaris aquatica* dominate areas that were previously natural swamps.

Protected areas in the NSW South-western Slopes Bioregion

As of mid-2008 the NSWSWS Bioregion contained a total of 105 protected areas, comprising 56 public conservation reserves and 48 secure property agreements and one private reserve. Most of these areas are shown in Figure 43. The summed area of these protected areas is 153,350 ha or approximately 1.9% of the bioregion (Table 6) (Figure 44). For NSW as a whole, over 500,000 ha of land have been added to the conservation reserve system in NSW between early 2006 and mid-2008 (compare Table 6 here to Table 9 on page 425 in Benson et al. 2006). Most of these new reserves have been dedicated in the Brigalow Belt South Bioregion to the north of the NSWSWS.

If it is assumed that approximately 20% of woody native vegetation remains in the NSWSWS Bioregion (i.e. about 1,600,000 ha), then less than 10% (about 153,000 ha) of this is in protected areas. While the average size of all protected areas is 1,460 ha, most are far smaller in size, with National Parks and Nature Reserves generally being larger than secure property agreements (Figure 44).

As of mid-2008, the protected areas in the NSWSWS Bioregion included nine National Parks, 30 Nature Reserves, five State Conservation Areas, one Aboriginal Area, one Karst Conservation Reserve, seven Flora Reserves under the NSW Forestry Act 1916, three Historic Sites, one Australian Bush Heritage private reserve, 13 Conservation Agreements (VCAs) under the NSW National Parks and Wildlife Act 1974 and at least 35 secure (99 year) property agreements that were entered into under the NSW Native Vegetation Conservation Act 1998 where they contained areas with the management remnant codes: MEV, MNF and MRZ and the "Improve" codes MNR and MRP. It is possible that other secure property agreements in perpetuity have been entered into under the NSW Native Vegetation Act 2003 since 2004.

A number of protected areas that either overlap with or occur near to the eastern or northern boundaries of the NSWSWS Bioregion have not been assessed in Version 2 of the NSWVCA. These include Razorback, Copperhannia, Burrinjuck, Black Andrew, Oak Creek, Wee Jasper Nature Reserves and Hill End Historic Site. Although the western fringe of the 690,000 ha Kosciuszko National Park overlaps with the NSWSWS Bioregion, this area will be covered in the NSWVCA as part of the South Eastern Highlands Bioregion. Munghorn Gap Nature Reserve occurs in the Sydney Basin Bioregion to the north-east while Dapper Nature Reserve and Goodiman State Conservation Area are mainly in the Brigalow Belt South Bioregion to the north. As the NSWVCA expands to cover more of NSW, plant communities in these reserves will be assessed and the protected area extent statistics in the NSWVCA database will be modified.

The majority of the 135 plant communities in the NSWSWS Bioregion are poorly represented in the protected area system. In fact, 24 (17%) plant communities are not sampled in protected areas; 50 (37%) have < 0.5%, 83 (61%) have <5% and 98 (73%) have <10% of their pre-European extent in protected areas (Table 7) (10% is an IUCN standard, IUCN 1994). If the protected area codes containing 1a, 1b, 1c, 2a, 2b, 2c, 3a, 3b, 3c are considered as moderately to well represented in protected areas (see definitions of these codes in pages 372–373 in Benson 2006), only 40 of the 135 (30%) plant communities fall into these categories (Table 8).

Table 7. NSW South-western Slopes Bioregion plant communities identified by their NSWVCA database ID number listed under a range of proportions of estimated percent of pre-European extent in protected areas.

Note: Includes occurrences of plant communities that extend to the NSW Tablelands and NSW Western Plains sections. Communities considered to be derived are in the 50–100% category because it is considered they either did not exist in 1788 or have expanded.

Protected pre-European Extent	**SWS VCA Veg. ID Numbers**	**No.**
0%	48, 83. 248, 269, 270, 301, 303, 319, 320, 335, 337, 338, 340, 343, 346, 350, 352, 353, 355, 356, 357, 358, 360	23
>0 - <0.2%	26, 55, 56, 70. 74, 76, 79, 80, 82, 201, 237, 238, 244, 258, 266, 267, 276, 333, 336, 339	20
0.2 - <0.5%	75, 251, 277, 281, 283, 312, 318	7
0.5 - <1%	110, 243, 256, 257, 275, 345	6
1 - <2%	5, 53, 77, 177, 182, 249, 268, 273, 280, 282, 285, 326, 348, 351	14
2 - <5%	54, 85, 185, 274, 284, 287, 298, 302, 304, 341, 344, 349	12
5 - <10%	2, 9, 57, 176, 193, 217, 272, 279, 286, 289, 290, 299, 316, 321, 332, 342, 347	17
10 - <15%	178, 181, 278, 291, 307, 323, 324, 327	8
15 - <20%	173, 293, 294, 314, 315, 317, 330	7
20 - <50%	186, 250, 292, 296, 297, 305, 306, 309, 311, 322, 325, 328, 331, 334, 354	15
50 - <100%	288, 295, 300, 310, 313, 329	6

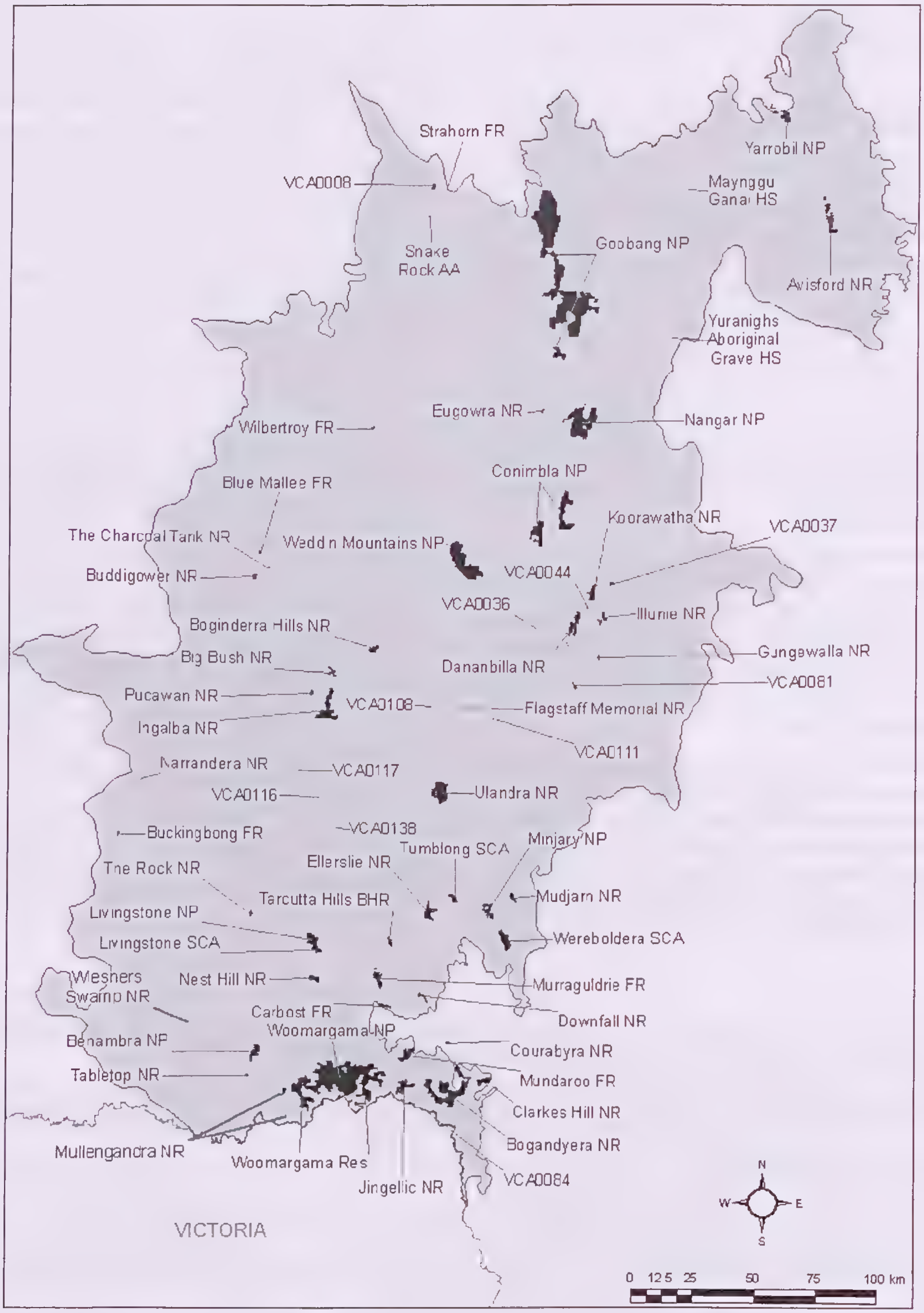

Fig. 43. The location of conservation reserves and conservation agreements under the National Parks and Wildlife Act 1974, Flora Reserves under the NSW Forestry Act 1916 and the Tarcutta Bush Heritage Reserve in the NSW South-western Slopes Bioregion as of March 2008. This excludes the western edge of Kosciuszko National Park and a number of secure property agreements under the Native Vegetation Act 2003.

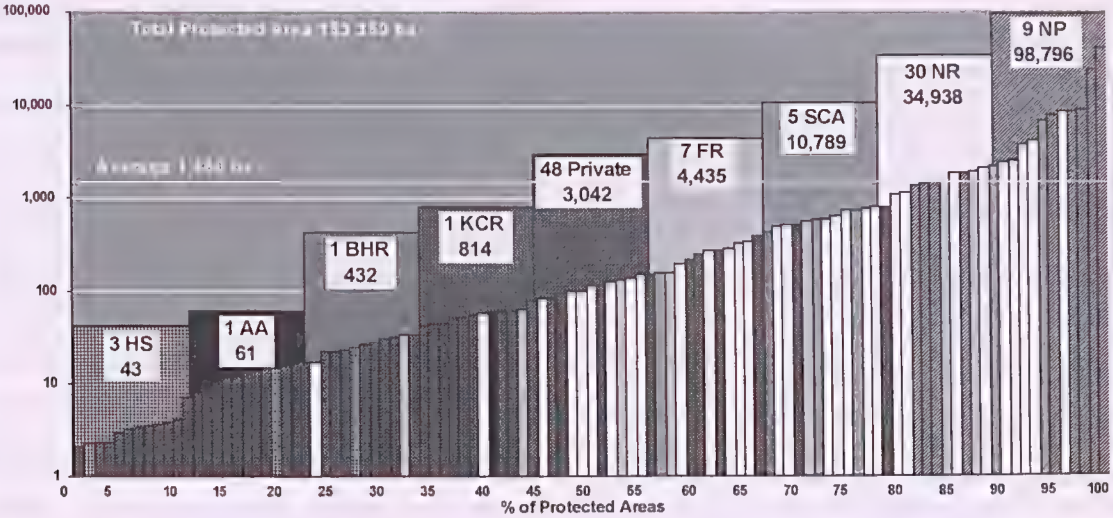

Fig. 44. Size (in hectares) of protected areas in the NSW South-western Slopes Bioregion (as of April 2008 assuming all DECC acquired lands at that time are added to reserves). This includes parts of protected areas that overlap with other bioregions with the exception of Kosicuszko National Park which is excluded. Thin columns in foreground are the areas of individual protected areas. Wide columns in background contain the cumulative area for each type of protected area . The number, type and area of each protected area type are shown in the white boxes. Columns are: HS (diamond-pattern) = Historic Sites, AA (black) = Aboriginal Area, Private (brick pattern) = secure private property agreements (under N P & W Act and Nat. Veg. Act), FR (light grey) = Flora Reserves, , SCA (dark grey) = State Conservation Areas, , NR (white) = Nature Reserves, NP (diagonal stripe) = National Parks.

Table 8. Number of plant communities in threat categories in relation to protected area codes.

Notes: Explanations of the protected area and threat codes are provided in Benson (2006). See Appendix B in Benson (2006) for explanation of the threat categories.

	No. of Extant NSW SWS Plant Communities															
	Protected Area Code															
Threat Category	**1a**	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**	**3c**	**4a**	**4b**	**4c**	**5a**	**5b**	**5c**	**Total**
Critically Endangered	-	-	-	-	-	-	-	-	-	1	-	-	10	5	2	18
Endangered	-	-	-	-	-	-	2	-	-	6	1	-	12	11	1	33
Vulnerable	-	-	-	-	-	-	6	-	-	8	1	1	6	5	2	29
Near Threatened	2	-	-	1	-	-	4	1	-	3	3	-	5	2	-	25
Least Concern	9	2	1	-	2	-	4	1	2	3	2	2	-	1	1	30
Total	11	2	1	5	2	-	16	2	2	21	7	3	33	24	6	135

Fig. 45. Most conservation reserves in the NSW SWS Bioregion are situated on hillcrest and rocky ranges that contain the largest patches of remnant native vegetation such as Ulandra Nature Reserve. Photograph, John Benson, 14/10/2002.

Fig. 46. The rare *Senecio garlandii* in ID293 *Eucalyptus nortonii – Dodonaea viscosa* subsp. *cuneata* woodland in Benambra National Park, 35°46'59" S 147°04'50" E. Photograph, Jaime Plaza, 19/10/2002.

Table 9. NSW South-western Slopes Bioregion plant communities that are part of Endangered Ecological Communities listed or nominated under the NSW Threatened Species Conservation Act 1995 and/or the Australian Environmental Protection and Biodiversity Conservation Act 1999 as of March 2008.

Note: The plant communities defined in the NSWVCA do not match directly with the definitions of listed or nominated endangered ecological communities.

ID No	Common Name	TSC Act	EPBC Act
26	Weeping Myall open woodland of the Riverina and NSW South-western Slopes Bioregions	Listed	Listed
54	Buloke – White Cypress Pine woodland in the NSW South-western Slopes Bioregion	Nominated	Listed
76	Inland Grey Box tall grassy woodland on alluvial loam and clay soils in the NSW South Western Slopes and Riverina Bioregions	Listed	Nominated
77	Yarran shrubland on peneplains and alluvial plains of central NSW	Nominated	-
80	Inland Grey Box – White Cypress Pine tall woodland on loam soil on alluvial plains of NSW South-western Slopes and Riverina Bioregions	Listed	Nominated
82	Inland Grey Box – Poplar Box – White Cypress Pine tall woodland on red loams mainly of the eastern Cobar Peneplain Bioregion	Listed	Nominated
110	Inland Grey Box – Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes and Riverina Bioregions	Listed	Nominated
177	Blue Mallee – Bull Mallee – Green Mallee very tall mallee shrubland of the West Wyalong region, NSW South-western Slopes Bioregion	Nominated	-
178	Broombush – Green Mallee – Blue Mallee very tall shrubland on stony rises in the NSW South-western Slopes Bioregion	Nominated	-
201	Fuzzy Box – Inland Grey Box on alluvial brown loam soils mainly in the NSW South-western Slopes Bioregion	Listed	-
237	Riverine Inland Grey Box grassy woodland of the semi-arid (warm) climate zone	Listed	-
266	White Box grassy woodland mainly on hills in the Upper Slopes Sub-region of the NSW South-western Slopes Bioregion	Listed	Listed
267	White Box – White Cypress Pine – Inland Grey Box shrub/grass/forb woodland in the NSW South-western Slopes Bioregion	Listed	Listed
274	White Box – Rough-barked Apple alluvial woodland of the NSW central western slopes including in the Mudgee region	Listed	Listed
275	Herbaceous White Box – Apple Box valley woodland of the NSW central western slopes	Listed	Listed
276	Yellow Box grassy tall woodland on alluvium or parna loams and clays on flats in NSW South-western Slopes Bioregion	Listed	Listed
277	Blakely's Red Gum – Yellow Box grassy tall woodland of the NSW South-western Slopes Bioregion	Listed	Listed
278	Riparian Blakely's Red Gum – box – shrub – sedge – grass tall open forest of the central NSW South-western Slopes Bioregion	Listed	Listed
279	Blakely's Red Gum – White Cypress Pine woodland on footslopes of hills in central part of the NSW South-western Slopes Bioregion	Listed	Listed
282	Blakely's Red Gum – White Box – Yellow Box – Black Cypress Pine box grass/shrub woodland on clay loam soils on undulating hills of central NSW South-western Slopes Bioregion	Listed	Listed
303	Black Sally grassy low woodland in valleys in the Upper Slopes Sub-region of the NSW South-western Slopes Bioregion and western South Eastern Highlands Bioregion	Nominated	-
304	Candlebark – Apple Box – Narrow-leaved Peppermint tall open forest on granite in the Tumbarumba region of the South East Highlands and upper NSW South-western Slopes Bioregions	Nominated	-
312	Yellow Box grassy tall woodland on valley flats in the Upper Slopes of the South-western Slopes Bioregion and South Eastern Highlands Bioregion	Listed	Listed
320	Kangaroo Grass – Redleg Grass rich-herb temperate tussock grassland of the northern Monaro, ACT and upper Lachlan River regions of the NSW South Western Slopes and South Eastern Highlands Bioregions	-	Nominated
347	White Box – Blakely's Red Gum shrub/grass woodland on metamorphic hillslopes in the mid-southern part of the Upper Slopes Sub-region of the NSW South-western Slopes Bioregion	Listed	Listed
350	Candlebark – Blakelys Red Gum – Long-leaved Box grassy woodland in the Rye Park to Yass region of the NSW South-western Slopes and South-Eastern Highland Bioregions	Nominated	-
355	Bull Mallee – White Mallee tall mallee woodland on red sandy loam soils in the central western slopes of NSW	Nominated	-

A minority of 38 (28%) plant communities have > 10% of their pre-European extent in protected areas and are considered to be adequately represented (Table 7). These mainly occur in reserves on steep hills and north-south strike ranges where the largest areas of native vegetation remain (Figure 45). These hills and ranges contain low nutrient, shallow soils derived from sandstone, granite, adamellite, conglomerate and some metamorphic rocks such as phyllite and quartzite. They support hill red gum, Currawang, Black Cypress Pine, heath, Red Stringybark, Red Box, Scribbly Gum and Ironbark dominated plant communities. Grassy woodlands that occur on high nutrient soils on floodplains, alluvial plains, valley flats and undulating hills landforms are mainly cleared and consequently are very poorly sampled in the protected area system.

A correlation of protected area status with threat categories is presented in Table 8. This shows that very few of the most endangered plant communities are well represented in the protected area system.

Assessment of threats to the vegetation

As mentioned in the Introduction, clearing of over 80% of the NSWSWS Bioregion (Figure 5) has led to severe land degradation and loss of biodiversity (NPWS 2001, Benson 1999). The degree of clearing, combined with heavy grazing and the dominance by exotic ground cover plant species over a large proportion of the bioregion, has lead to a high number of plant communities being categorised as threatened (critically endangered, endangered, vulnerable) in applying the NSWVCA threat criteria (Appendix B in Benson 2006). Applying these threat criteria to the 135 NSWSWS Bioregion plant communities resulted in 18 communities being considered as critically endangered (CE), 33 endangered (E), 29 vulnerable (V), 25 near threatened (NT) and 30 least concern (LC) (Table 8). This implies that 59% of the plant communities fall into the threatened categories (CE, E, or V).

As of April 2008, a total of 18 plant communities were part of endangered ecological community (EEC) listings and a further eight were part of nominated EECs under the NSW *Threatened Species Conservation Act 1995* (Table 9). Concerning the Australian Government *Environmental Protection and Biodiversity Conservation Act 1999*, 17 plant communities were part of its EEC listings and one other was part of an EEC nomination (Table 9). A number of other NSWVCA plant communities recorded in the NSWVCA for the NSWSWS Bioregion warrant nominations and listing as EECs under these laws. These include *Eucalyptus bridgesiana* (Apple Box) grassy valley woodlands (including ID283 & ID298); *Eucalyptus rubida – Eucalyptus robertsonii – Eucalyptus bridgesiana* tall woodland on granite east of Tumbarumba (ID304); *Eucalyptus camphora* subsp. *humilis* (Broad-leaved Sallee) woodland along creeks in the Tumbarumba regions (ID285) and the small gilgai wetlands around Albury and Holbrook (ID360).

A total of 36 plant species in the NSWSWS Bioregion were listed as threatened under the NSW *Threatened Species Conservation Act* in NSW NPWS (2001). Examples of threatened plant species in NSWSWS plant communities are *Senecio garlandii* (Figure 46) occurring in ID293 *Eucalyptus nortonii – Dodonaea viscosa* subsp. *cuneata* woodland in Benambra National Park and in ID186 Dwyer's Red Gum – Currawang low woodland in The Rock Nature Reserve; and *Lepidium aschersonii* in ID355 Bull Mallee – White Mallee mallee woodland near Wyalong. Concerning threatened fauna, 49 species of vertebrates have been recorded from the NSWSWS Bioregion, listed in NSW NPWS (2001).

The number of plant communities in different threat categories in the four CMAs that intersect the NSWSWS Bioregion is presented in Table 10. This excludes plant communities

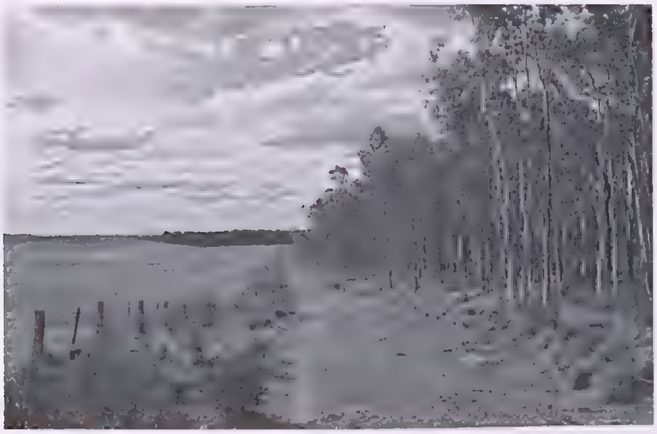

Fig. 47. Illustration of a sharp boundary of native vegetation to cleared grazing land, southern side of Nest Hill Nature Reserve, north of Holbrook. Photograph, Jaime Plaza, 15/10/2002.

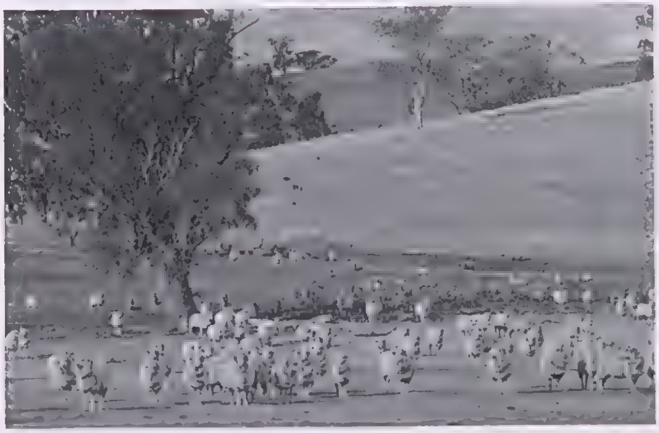

Fig. 48. Sheep grazing of a *Eucalyptus melliodora* (Yellow Box) woodland flat near Jugiong, NSW SWS Bioregion. Over-grazing has lead to extensive loss of ground cover and lack of regeneration of native vegetation. Photograph Jaime Plaza, 29/4/2006.

that are yet to be classified in the NSWVCA that occur on the NSW Tablelands Section in these CMAs. Table 10 also provides an update of the two western CMAs (Western and Lower Murray-Darling) from Version 1 of the NSWVCA (Benson et al. 2006). Most threatened plant communities in the two Western Plains CMAs (Western and Lower-Murray Darling) are located in the eastern (mostly cleared) parts of the CMA areas with some overlapping into the NSWSWS Bioregion. Concerning the four CMAs that transect the NSWSWS Bioregion, threatened plant communities occur throughout the cross-matched areas.

The degree of clearing in the NSWSWS Bioregion has resulted in highly fragmented native vegetation on floodplains, alluvial plains, in valleys, and on gentler sloping low rises or hill landform patterns with high to medium nutrient soils. In one study area near Holbrook, Gibbons & Boak (2002) calculated that over 30% of the total area of woody native vegetation was contained in patches less than one hectare in size (paddock trees) and about 70% was in patches less than 50 ha in size. Gibbons & Boak (2002) calculated that 54% of the woodland dominated by White Box, Yellow Box and Blakely's Red Gum (mainly IDs 266 and 277 in the NSWVCA) were in patches <1 ha. Therefore, paddock trees were found to dominate landscapes with higher nutrient soils and gently undulating terrain. The removal of paddock trees or the ploughing of remnant native ground cover would therefore have substantial impacts on the remaining extent of some types of vegetation such as grassy White Box woodland (ID266).

In contrast, Gibbons & Boak (2002) documented that the largest patches of native vegetation (>50 ha) were found on rocky ranges and steep hills. Clearing to the boundaries of state forests and conservation reserve boundaries (Figure 47) on these hills has led to sharp contrasts in vegetation structure and condition across those boundaries. This fragmentation and isolation of vegetation remnants can lead to reduced genetic diversity of species that comprise major components of plant communities. For example, Prober & Brown (1994) reported that genetic diversity was significantly lower in *Eucalyptus albens* (White Box) populations that contained less than 400–500 trees or about 13 hectares, assuming a tree density of 40 trees per hectare.

Continuous heavy grazing on better soils on alluvial flats (Figure 48) and on shallow soils in hilly country (Figure 49) has led to sheet and gully erosion (Figure 50) and invasion by exotic plant species (Prober & Thiele 1995). Increased fertiliser use since World War II combined with the introduction of exotic pastures caused a shift in ground species composition from perennial native grasses and forbs to annual species (Moore 1953). Typical Upper Slopes Sub-region perennial grass species such as *Themeda australis* and *Poa sieberiana* have been replaced by various species of *Austrostipa* and *Austrodanthonia* and as disturbance continued by exotic grasses such as *Bromus*, *Hordeum* and *Lolium* spp. (Prober & Thiele 1995).

Today, broad-scale clearing of native vegetation has ceased over most of the extent of the NSWSWS Bioregion and some landholders are planting indigenous trees and shrubs or allowing regrowth to occur. The exception to this is the tens of thousands of hectares of scattered native trees and ground cover on former farms being cleared for pine plantations in the Tumut and Tumbarumba regions in the south-eastern corner of the NSWSWS Bioregion (Figure 51). These pine plantations are impeding linkages of native vegetation between the NSWSWS Bioregion and the large biosphere reserve of Kosciuszko National Park to the east in the South Eastern Highlands and Australian Alps Bioregions.

One of the main drivers of changing attitudes among landholder towards native vegetation has been the impact of salinity on farm production (Littleboy et al. 2001). Salinity compounds the primary threats of clearing, fragmentation and weed invasion in valley vegetation remnants. Upper Slopes catchments are particularly affected by salinity with the Boorowa River catchment being particularly saline (Hayman 1996). In the Boorowa Shire, nearly 2000 ha of woody vegetation are impacted by salinity and much of this is concentrated in over-cleared grassy woodland communities such as ID277 *Eucalyptus blakleyi* (Blakely's Red Gum) – *Eucalyptus melliodora* (Yellow Box) woodland that occurs on lower hill-slopes and on river flats (Seddon et al. 2007). Salinity has also affected species composition with exotic species such as the rush *Juncus acutus* (Figure 42) invading valley swamps in the Boorowa to Young regions in the Lachlan catchment.

Too frequent fire or lack of fire may threaten key species in some plant communities. While clearing and fragmentation over the last 100 years has prevented regular widespread wildfires burning large regions, some types of vegetation are susceptible to intense fire. For example, in the summer of 2006 a fire burnt *Eucalyptus camaldulensis* (River Red Gum) lake woodland (ID249) at Nerang Cowal near Forbes possibly killing many of the River Red Gum trees (Figure 52). It is unknown whether this woodland will recover or how long this will take.

The least threatened vegetation types occur on steep, rocky hills mostly in the Upper Slopes Sub-region with some outliers in the Lower Slopes Sub-region. The most common of these communities is ID186 (Figure 36), ID309 and ID317 (Figure 37) dominated by tree species such as *Eucalyptus dwyeri*, *Eucalyptus dealbata*, *Callitris endlicheri* and *Acacia doratoxylon*. Other non-threatened hill communities include some of the ironbark woodlands, Red Stringybark and Scribbly Gum open forests, Red Box and Long-leaved Box open forests in hills and Eurabbie tall open forest. Some of these communities are well protected in conservation reserves.

Table 10. Number of NSWVCA plant communities with different threat categories in Central West, Lachlan, Murrumbidgee, Murray Catchment Management Authority areas that intersect the NSW south-western Slopes Bioregion and the NSW Western Plains. The two western CMAs* (Western and Lower Murray-Darling) are also included with updated information from Benson et al. (2006).
Notes: Figures in brackets ( ) indicate the number of plant communities (of the total) that are restricted to a single CMA area. This assessment does not represent the entire list of plant communities in the Central West, Lachlan, Murrumbidgee, Murray CMAs because these CMAs extend eastwards into the South Eastern Highlands and the Australian Alps Bioregions. Also, a small part of the Central West CMA lies within the Brigalow Belt South and Nandewar Bioregions. See Appendix B in Benson (2006) for an explanation of the threat categories.

	No. of Extant NSW SWS Plant Communities						
	Catchment Management Authority Areas						
Threat Category Code	Central West	Lachlan	*Lower Murray/Darling	Murray	Murrumbidgee	*Western	Total SWS
Critically Endangered	8 (2)	10 (3)	4	10 (1)	11 (1)	4 (1)	18 (7)
Endangered	15 (2)	24 (2)	3	12 (2)	21 (2)	16 (2)	33 (8)
Vulnerable	14 (2)	22 (2)	10 (3)	13 (1)	17 (2)	15 (1)	29 (7)
Near Threatened	9 (1)	12 (1)	20 (1)	14	18	50 (18)	25 (2)
Least Concern	18 (5)	18 (1)	23 (4)	12 (4)	12	68 (41)	30 (10)
Total	64 (12)	86 (9)	60 (8)	61 (8)	79 (5)	153 (63)	135 (34)

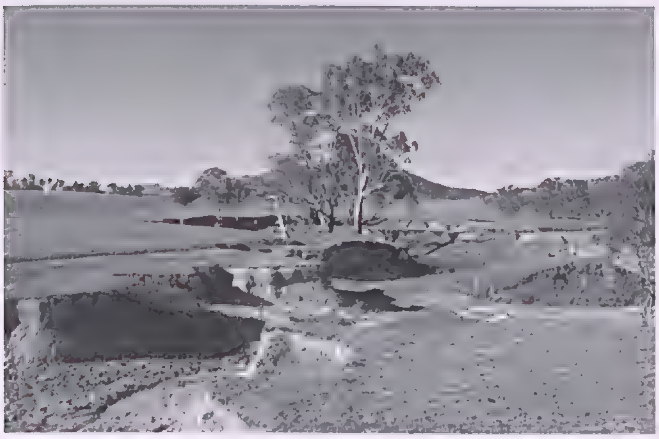

Fig. 49. Over-clearing and over-grazing have lead to gully soil erosion on some soils such as this grey clay on cleared hills south of Ulandra Nature Reserve 34° 54' 24" S 147° 51' 51" E. Photograph, Jaime Plaza, 14/10/2002.

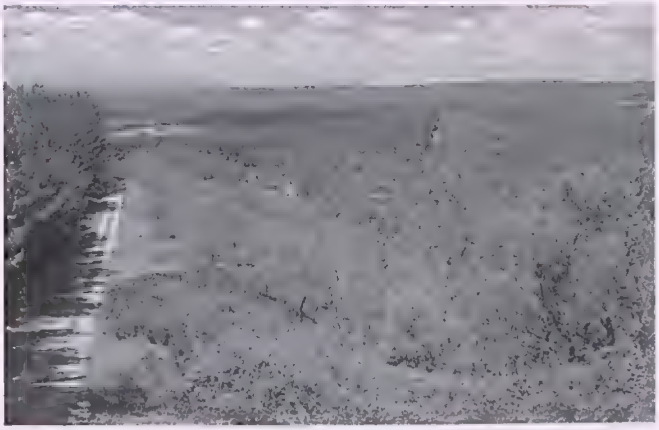

Fig. 51. Pine plantations surrounding a native vegetation remnant in Carobost Flora Reserve, in the southern-eastern corner of the Upper Slopes Sub-region of the NSWSWS Bioregion. Photograph, Jaime Plaza, 17/10/2002.

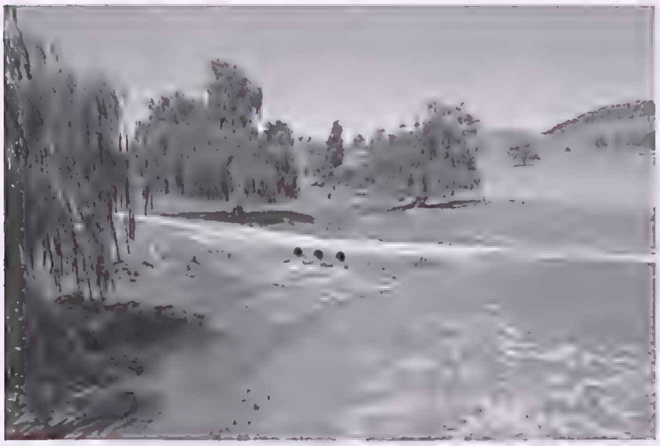

Fig. 50. Gully and sheet soil erosion with willow (*Salix*) infestation in Milburn Creek east of Cowra during a severe drought. Photograph, John Benson, 12/2/2007.

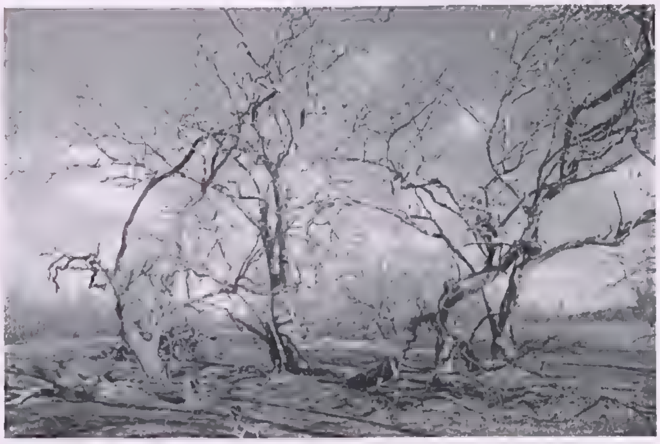

Fig. 52. Burnt and killed *Eucalyptus camaldulensis* (River Red Gum) (ID249) on Nerang Cowal west of Forbes, (AGD66) 33° 51.999' E 147° 24.973' S. Photograph, Jaime Plaza, 31/5/2007.

Management and conservation priorities

While it should be possible to increase the current 1.9% of the NSW SWS Bioregion in protected areas, the proportion of protection will be constrained by less than 20% of the native vegetation remaining in the Bioregion and much of it being in highly fragmented, small patches. Also, many plant communities have been over-cleared to the extent that less than 10% of their pre-European extent remains. Therefore, for most plant communities it will not be possible to meet the reservation target requirement of 10% of pre-major loss of extent in protected areas that is recommended by IUCN (1994).

As mentioned above, plant communities occurring on rocky ranges or steep hills are relatively intact and many are well sampled in protected areas. In contrast, grassy woodlands such as grassy White Box woodland (ID266) (Figure 19), Blakely's Red Gum – Yellow Box woodland (ID277) (Figure 20), grassy Apple Box valley woodland (Figure 21), Yellow Box flats woodland (ID74, 276) (Figure 8), Inland Grey Box woodland (ID76) (Figure 9) and Fuzzy Box woodland (ID201) are very poorly represented in reserves, infested with exotic ground cover species and are mainly cleared.

The best remaining examples of these grassy woodland communities occur in cemeteries and travelling stock reserves (Prober & Thiele 1995). A concerted effort to influence off-reserve management of grassy box woodland, through, for example, the NSW Grassy Box Woodlands Conservation Management Network (www.gbwcmn.net.au), has raised public awareness and realised a number of secure property agreements over good condition remnants on both private land and public land tenures. The latter include conservation agreements over cemeteries such as Monteagle Cemetery in the Young Shire and Stockinbingal, North Berri Jerri and Marra Cemeteries in the Coolamon Shire. More secure property agreements are required over private land to raise the levels of protection of grassy box woodlands and to form larger patches and native vegetation corridors for long term landscape management.

Preventing the detrimental practice of persistent grazing of high quality remnant grassy woodland is critical to protecting native plant ground and shrub species. On public lands, this could include preventing biologically important travelling stock reserves from being leased or sold off for continuous grazing. Fencing is a key management tool because it usually leads to regeneration of native perennial trees and native grasses and protects the soil from compaction by domestic stock (Spooner & Briggs 2008).

Given the impacts of edge effects on vegetation condition and the implications of small populations of plants in small patches of bushland on genetic diversity, increasing the size of patches should be one of the primary aims of revegetation over the next 50 years. Increasing patch size and connectively of vegetation remnants should help protect woodland bird species as pointed out in Reid (1999) and Freudenberger (1999) who noted that small vegetation remnants of <5 ha fail to support sensitive woodland bird species unless the patches are connected to other remnants. Investment strategies in re-vegetation schemes could focus on enlarging existing remnants and developing naturally vegetated links between remnants, taking into account long term ramifications of climate change on plant and animal species distributions. This may need to include corridors through pine forests in the Tumut to Tumbarumba region to ensure native vegetation links remain from the western plains to the south eastern highlands and minimise impacts of fragmentation on fauna (Lindenmayer et al. 1999).

The clearing of isolated native paddock trees or small remnants should be minimised because it leads to a reduction in plant species associated with native trees (Prober & Thiele 1995). Setting priorities for investing in the regeneration of native vegetation on private land will require site condition assessments using the approaches summarised in Gibbons & Freudenberger (2006). Initiatives such as local landscape biodiversity plans (Davidson 2007) that emphasises recoverability based on ground cover naturalness and connectivity would assist implement ecological restoration at local scales.

Changes to NSW Western Plains NSWVCA Version 1

One of the challenges of the NSWVCA database system is keeping track of new literature and changes in the NSW protected area system. Many minor changes, such as typographical errors or species name changes, have been made to the 213 NSW Western Plains plant communities published in the 2006 Version 1 of the NSWVCA database (Benson et al. 2006). Most of these changes are due to feedback on the 2006 Version 1 publication and changes to boundaries or names of conservation reserves. Key changes are kept in a register spreadsheet on the Royal Botanic Gardens Sydney web site at: http://www.rbgsyd.nsw.gov.au/science/hot_science_topics/vegetation_of_nsw

Six plant communities have been added to the 213 listed in Version 1 of the NSWVCA published in Benson et al. (2006). These are:

ID359 *Tridoia scariosa* (Porcupine Grass) – *Eucalyptus socialis* (Red Mallee) – *Eucalyptus intertexta* (Gum Coolibah) hummock grassland / low sparse woodland on the pre-Cambian metamorphic ranges in the southern Barrier Range sub-region, north of Silverton;

ID363 Swamp Paper-bark sodic scald wetland / shrubland of the Yetman – Yalarbon region;

ID364 Wetlands on sodic soils in the Yetman–Yelarbon region; ID377 Coppurburr low open shrubland on loam - clay flats and playas in the Narran Lake region north of Walgett;

ID375 Budda Pea – Channel Millet ephemeral shrubland / reedland grassland wetland on floodplains in north-western NSW;

ID376 Mixed scrub low open woodland on sand rises on floodplains in the DRP & BBS Bioregions;

ID377 Copperburr low open shrubland on loam – clay flats and playas in the western BBS and northern DRP Bioregions.

Revisions to the distribution of plant communities since Version 1 was published have resulted in 30 plant communities being added to the list of plant communities in the Western CMA (now totalling 153 communities) and two communities have been added to the communities listed in the Lower Murray-Darling CMA (now totalling 60 plant communities) (Table 5). It is important that the PVP Biometric tool is regularly updated with these changes so that CMA property planning decisions are based on the latest NSWVCA version.

A number of western NSW conservation reserve changes have required changes to the statistics on areas of plant communities in reserves. Gundabooka National Park, near Bourke, is now split between Gundabooka National Park and Gundabooka State Conservation Area. Similarly, Yanga National Park near Balranald is split between Yanga National Park, Yanga State Conservation Area and the original Yanga Nature Reserve. Extents and descriptions of some plant communities have changed for reserves that have been subjected to botanical survey and mapping since 2006. This includes plant communities recorded in Budelah, Boomi, Boomi West, Boronga Nature Reserves and additions to Culgoa National Park in the Darling Riverine Plains Bioregion; Narran Lake, Midkin and Careunga Nature Reserves in the Brigalow Belt South Bioregion; additions to Ledknapper Nature Reserve and Paroo-Darling National Park in the Mulga Lands Bioregion. Revised reports from Version 2 of the NSWVCA database for each of the eight bioregions and the two western-most CMAs in the NSW Western Plains Section are provided in Folders 3 and 4 on the CD.

Future progress of and improvements to the NSWVCA

As mentioned in the Introduction, the NSWVCA has covered 9 of the 18 IBRA Bioregions (Thackway & Cresswell 1995, Version 6) in NSW (Figure 1). The vegetation in the Brigalow Belt South and Nandewar Bioregions (NSW North-western Slopes) and the western half of the New England Tableland Bioregion are currently being classified and assessed for Version 3 of the NSWVCA. The three tablelands bioregions (eastern New England Tableland, South Eastern Highlands and Australian Alps) need to be covered by the NSWVCA to yield a complete vegetation classification of the six CMAs that run westwards off the NSW Great Dividing Range and a tablelands coverage of the four coastal CMAs. The biologically complex eastern escarpment and coast vegetation, with about 1000 protected areas, will require teams of experts and several years to complete. However, the east coast could be completed concurrently with the NSW Tablelands Section with the records merged to form a single database vegetation classification covering all of NSW.

It is anticipated that between 1200 and 1400 plant communities would be described if all of NSW was covered by the NSWVCA project. The classification could be expanded to include marine algae and freshwater algae communities if they can be defined.

There are a number of enhancements that could be made to the NSWVCA database including:

Expanding the number of species used in the search routine of Latin species names in the Scientific Name field and English names in the Common Name field. Using more indicative characteristic species in the search routine would reduce the list of candidate plant communities in site assessments;

Developing a matrix key to the plant communities using software such as DELTA (Dallwitz et al. 1993). This would filter information fields such as characteristic species, vegetation structure, soils, substrate, geographical location and photographs to key out plant communities from the NSWVCA database. A key would particularly help people doing site assessments;

Adding a "sample plot reference" field that lists typical plot data that help to define and describe the plant community. This could link directly to the DECC NSW YETI floristic plot (site) data database;

Adding a separate species field that lists species with positive fidelity to a plant community derived through analyses of plot data. This would enhance the vegetation description;

Link the species listed in the NSWVCA database characteristic species fields to the NSW National Herbarium Botanic Gardens Trust species database EMU and its internet derivative BGT Plant Net species information system (http://www.rbgsyd.nsw.gov.au/plant_info/Plant_databases). This would allow access to taxonomic information and images of plant community characteristic plant species;

To increase geo-referencing, in the NSWVCA database, citations of vegetation maps entered in the Authority database field could be hot-linked to image or GIS files of relevant vegetation maps. These maps may or may not cover total the total extent of a community or be defined at the same level of classification as the NSWVCA;

Improve visual representation of the landscape position of the plant communities by inserting an extra database field that contains "reference" latitude and longitudes that can automatically link to Google Earth or NSW Government satellite imagery. This would provide a "sky view" of some areas of each plant community via remote sensing technology;

To improve the relationship with the NSW Biometric Tool used in property planning (Gibbons et al. 2005) (http://www.nationalparks.nsw.gov.au/npws.nsf/Content/biometric_tool), the vegetation structure section of the database could expand to include more vegetation strata to cater for the more complex structure of eastern NSW forests. Database fields on other aspects of vegetation structure such as benchmarking number of logs on the ground, average number of tree hollows, average stem density, could also be added.

As mentioned in Benson (2006), memory limits in MS Access software restrict the size of the plant community images that can be linked to the database for generating multi-record PDF reports. Also, the database cannot be web-enabled in its present software. Recent reviews of NSW Department of Environment and Climate Change vegetation information systems have recommended reconstruction of the NSWVCA database in more robust database software to over come these and other deficiencies. It is likely the MS Access NSWVCA database will be upgraded to MS SQL software and web-enabled within two years. This may negate the need to produce regular CD versions of the NSWVCA database as it progresses across NSW. However, a MS Access version may be occasionally published or made available for use on personal computers where internet connection is unavailable or of poor quality.

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Note: A bibliography of all references used in the classification and assessment of the vegetation of the eight bioregions that comprise the previously published NSW Western Plains (Benson et al. 2006), the NSW South-western Slopes Bioregion and some areas of the NSW north-western slopes, is presented in the spreadsheet file *NSWVCA Version 2 Bibliography.xls* in Folder 2 on the CD in the back pocket of this journal. The references listed below are those cited in this paper.

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Appendix A. ID266: Full report (90 fields) of a grassy box woodland with an originally large extent and wide distribution that is now mainly cleared, weed invested and is assessed as being Endangered.

Veg. ID No.	266
Common Name	**White Box grassy woodland mainly on hills in the upper slopes sub-region of the NSW South-western Slopes Bioregion**
Scientific Name	*Eucalyptus albens / Acacia decora – Acacia implexa – Acacia deanei subsp. paucijuga / Themeda australis – Poa sieberiana – Wurmbea dioica – Cymbonotus lawsonianus*
Original Data Entry	J. S. Benson
Original Data Entry Date	10/01/2006
Last Modified By	NA
Last Modified Date	NA
Formation Group	Eucalyptus (Mostly Grassy) Box Woodlands of the Tablelands and Western Slopes
State Veg Map (Keith 2004)	Western Slopes Grassy Woodlands;
State Landscapes (Mitchell 2002)	Not correlated
NVIS Major Veg Sub-Groups	Eucalyptus woodlands with a grassy understorey;
Forest Type (RN 17)	175 – White Box (P);
Characteristic Trees	*Eucalyptus albens; Eucalyptus bridgesiana; Brachychiton populneus subsp. populneus;*
Characteristic Shrubs/Vines/ Epiphytes	*Acacia decora; Acacia implexa; Acacia deanei subsp. paucijuga; Acacia genistifolia; Acacia penninervis var. longiracemosa; Acacia buxifolia subsp. buxifolia; Acacia paradoxa; Dodonaea viscosa subsp. cuneata; Bursaria spinosa subsp. spinosa; Cassinia aculeata; Hibbertia riparia*
Characteristic Groundcover	*Themeda australis; Poa sieberiana; Wurmbea dioica; Cymbonotus lawsonianus; Aristida behriana; Panicum effusum; Austrodanthonia auriculata; Austrodanthonia caespitosa; Microlaena stipoides; Austrostipa bigeniculata; Bothriochloa macra; Elymus scaber var. scaber; Aristida ramosa; Enteropogon acicularis; Austrostipa aristiglumis; Austrodanthonia monticola; Gonocarpus elatior; Oxalis perennans; Lomandra filiformis subsp. coriacea; Lomandra multiflora; Dianella longifoila; Tricoryne elatior; Desmodium varians; Hydrocotyle laxiflora; Asperula conferta; Leptorhynchos squamatus sens. lat.; Craspedia variabilis; Podolepis jaceoides; Stackhousia monogyna; Dichopogon strictus; Velleia paradoxa; Diuris dendrobioides; Microtis uniflora; Cheilanthes sieberi subsp. sieberi; Acaena novae-zelandiae; Acaena ovina; Ajuga australis; Xerochrysum viscosa; Vittadinea cuneata; Wahlenbergia luteola; Solenogyne dominii; Scutellaria humilis; Ranunculus lappaceus; Rumex brownii; Plantago varia; Hypericum gramineum; Chrysocephalum apiculatum; Chloris truncata; Calotis cuneata var. cuneata; Glycine clandestina; Calotis lappulacea; Microseris lanceolata; Geranium retrorsum; Goodenia pinnatifida; Microseris lanceolata; Eryngium ovinum; Prasophyllum odoratum; Diuris dendrobioides*
Characteristic Weed Species	*Hypochaeris radicata; Bromus hordeaceus; Vulpia muralis; Vulpia myuros; Avena fatua; Echium plantagineum; Trifolium campestre; Trifolium arvense; Plantago lanceolata; Phalaris aquatica; Carthamus lanatus; Lolium perenne; Dactylis glomerata; Anagallis arvensis; Briza minor*
Weediness	Very high (>30%) with >30% cover (average)
Threatened Plants	*Microseris lanceolata (depleted);*
Threatened Fauna	*Superb Parrot; Swift Parrot; Brown Treecreeper; Diamond Firetail; Pale-headed Snake; Striped Legless Lizard;*
Mean Native Species Richness	In good sites over 40 spp. in 20 X 20 m plots but such sites are rare.
Characteristic Qualifiers	Combination of Quantitative Data and Qualitiative Estimate
Authority(s)	Includes most of the White Box association in Moore (1953a). Includes Vegetation Group 31 in Gellie & Fanning (2004) and Vegetation Group 117 in Gellie (2005). Community 3 in Priday (2004) for Wagga Wagga Shire. Part of Biolandsapes BulS24 and SouV24 in Priday (2006). White Box woodland in Boorowa Shire (NSWNPWS 2002a). Community 74 (E. albens) in Austin (2001) for mid-Lachlan region. Probably most of the White Box woodland in Sedden et al. (2002) for the Little River Catchment. Much of the White Box community in Prober (1996) and Prober & Thiele (1995) Includes BVT78 in DEC (2006, 2006a). . A sub-formation that could be sub-divided with plot data analysis.
Authority Qualifiers	(Combination of Expert Opinion and Quantitative Data)
Interstate Equivalent(s)	Victoria: part of EVC 175–62 Rainshadow Grassy Woodland
Class. Confidence Level	High
Level of Classification	Sub-formation
Rainforest Structure (Webb)	Not applicable

Structure (WH)	Woodland;
Height Class (WH)	Tall;
Vegetation Description	Tall woodland with trees to 25 m high dominated by White Box (Eucalyptus albens) often as the only tree species. Kurrajong (Brachychiton populneus subsp. populneus) is often present, particularly on limestone or rocky ground. The shrub layer is usually sparse or absent depending on grazing history or soil type. Wattles are the most common shrubs including Acacia decora, Acacia implexa, Acacia pycnantha, Acacia deanei subsp. paucijuga, Acacia genistifolia, Acacia penninervis var. longiracemosa, Acacia buxifolia subsp. buxifolia and Acacia paradoxa. Other shrubs include Dodonaea viscosa subsp. cuneata, Bursaria spinosa subsp. spinosa and Cassinia spp. The ground cover is usually mid-dense to dense except during drought and may be very diverse in grass and forb species. Very few areas contain a native ground cover with a rich flora but where this occurs it typically contains grasses such as Themeda australis, Poa sieberiana, Elymus scaber var. scaber and a range of Austrodanthonia species including Monachather paradoxus and Austrodanthonia auriculata. Forbs in such sites include Wurmbea dioica, Gonocarpus elatior, Microseris lanceolata, Leptorhynchos squamatus sens. lat., Craspedia variabilis, Podolepis jaceoides, Hypericum gramineum, Stackhousia monogyna, Ranunculus lappaceous, Dichopogon strictus, Velleia paradoxa and Diuris dendrobioides. In heavily grazed sites fewer native species are present and the sites are dominated by Austrostipa spp, Aristida spp. and Austrodanthonia spp. Grasses with some hardy forbs such as Calotis spp. Xerochrysum viscosa, Vittadinea cuneata, Wahlenbergia luteola, Solenogyne dominii, Scutellaria humilis and Oxalis perennans. In sites exposed to continuous grazing, soil disturbance and fertilizer application, exotic species dominate the ground cover including Bromus spp., Vulpia spp., Avena fatua, Echium plantagineum, Trifolium spp. and Plantago lanceolata. Floristic composition varies from north to south and on different aspects and soil types. Occurs between 300 – 600 m altitude in the 500 – 700 mm rainfall zone, most of which falls in winter. The soils are mainly red-brown earths, red or yellow podsols with some brown and black earths. The soils are derived from a variety of lithologies including shale, limestone, fine grained metamorhic rocks, granite and basalt. Species composition appears not to vary greatly across these lithologies. Mainly occurs on hillslopes in low hill or hill landform patterns in the NSW South-western Slopes Bioregion overlapping into the South Eastern Highlands Bioregion. Most of this community has been cleared and most of the extent of ground cover has been replaced by exotic annual plant species. Sheet erosion has lead to top soil loss on heavily grazed slopes. Small areas with an "intact" ground cover remain in cemetries, roadsides and travelling stock reserves. While this community is poorly sampled in public reserves, some progress is being made in protecting remnants in non-reserve conservation measures. A highly threatened plant community due to ground cover change and clearing.
Mapped/Modelled	Current extent partly mapped
Mapping Info	Full range not mapped as of 2007. Mapped by Priday (2004) in Wagga Wagga Shire. Mapped in the Boorowa and Yass Shires and in some reserves. Difficult to discern a native understorey from an exotic understorey using aerial photos.
Adequacy Of Plot Sampling	Inadequate
Climate Zone	Temperate: no dry season (warm summer); Temperate: no dry season (hot summer);
IBRA Bioregion (v6)	NSW South-western Slopes (>70%); South Eastern Highlands (1–30%);
IBRA Sub-Region	Bondo (1–30%); Crookwell (1–30%); Lower Slopes (1–30%); Orange (1–30%); Upper Slopes (30–70%);
Botanical Division	Central Western Slopes (CWS) (30–70%); South Western Slopes (SWS) (30–70%);
Local Govt. Areas	Albury (1–30%); Bland (1–30%); Boorowa (1–30%); Cabonne (1–30%); Coolamon (1–30%); Cootamundra (1–30%); Cowra (1–30%); Forbes (1–30%); Greater Hume (1–30%); Gundagai (1–30%); Harden (1–30%); Junee (1–30%); Parkes (1–30%); Temora (1–30%); Wagga Wagga (1–30%); Weddin (1–30%); Wellington (1–30%); Young (1–30%);
CMAs	Central West (1–30%); Lachlan (1–30%); Murray (1–30%); Murrumbidgee (1–30%);
MD Basin	Yes
Substrate Mass	Igneous rocks; Metamorphic rocks; Sedimentary rocks; Volcanic rocks;
Lithology	Basalt; Calcareous mudstone; Claystone; Granite; Hornfels; Jasper; Limestone; Mudstone; Phyllite; Schist; Shale; Slate;
Great Soil Group	Black earth; Chocolate soil; Red podzolic soil; Red-brown earth;
Soil Texture	Clay loam; Light clay; Light medium clay; Medium clay;
Landform Patterns	Hills; Low hills;
Landform Elements	Hillcrest; Hillslope; Valley flat;
Land Use	Cropping and Horticulture; Grazing;
Impacts of Euro. Settlement	Major alteration of species composition; Major reduction (>70%) in extent and /or range;
Pre-European Extent (ha)	800000
Pre-European Accuracy (%)	30
Pre-European Qualifiers	Estimated from pre-European map: part range

Pre-European Comments	Moore (1953a) mapped 1.1 million ha of pre-European White Box woodland from Young to Albury on the NSW south western slopes but this broad map includes several types of White Box woodland. However, this did not cover the northern extent of this community. The most widespread plant community in the NSW SWS Bioregion.
Current Extent (ha)	50000
Current Extent Accuracy (%)	30
Current Extent Qualifiers	Estimated from mapped extant vegetation: part range
Current Extent Information	Miniscule White Box woodland remains with a native ground cover but White Box paddock trees are common mostly with a weedy ground cover. The current extent estimate depends on whether one is recording "intactness of ground cover" or tree patch cover. Prober & Thiele (1993) state that only 0.01% of White Box woodland south of Molong remains relatively unmodified. NSWNPWS map 5584 of a predicted 30511 ha (18%)of White Box woodland in Boorowa Shire but this includes paddock patches. Seddon et al. (2002) estimate only 3% remains in the Little River Catchment.
Percent Remaining	6
Percent Remaining Accuracy (%)	±50
Degree of Fragmentation	Human induced highly fragmented small stands with <30% extent remaining and high edge to area ratio
Recoverability	Very poor health as structure and/or composition severely altered. Insufficient biota remain for natural regeneration except some ruderal species.
Threatening Processes	Highly fragmented due to past clearing. High nitrogen levels are common due to fertilizer use, coinciding with the intoduction of exotic pasture weeds replacing perennial native grasses and forbs. Few remnants contain a natural shrub or ground cover plant species composition.
Threat Process List	Age class of woody vegetation; Clearing for agriculture;Dryland cropping; Herbicides, pesticides or other chemical pollution; Nutrient changes through fertilizers or runoff; Salinity; Soil erosion, water: sheet erosion; Soil erosion, wind; Unsustainable grazing and trampling by stock; Weed (exotic) invasion;
Variation and Natural Disturbance	Occurs over a large range on many lithologies and a number of soil types. Floristic composition varies but Prober (1996) describes consistency in ground cover species composition with a gradual latitudinal change from south to northern NSW.
Adjoining Communities	Grades into and shares many ground species with Blakely's Red Gum – Yellow Box woodland (ID277) on lower hill-slopes and flats; into Fuzzy Box (Eucalyptus conica) woodland (ID201) on colluvial lower hill-slopes and flats; to the west into Inland Grey Box (Eucalyptus microcarpa) woodland (ID76 or ID80) on brown loams and clays and into shrubby White Box or Tumbledown Gum – Mugga Ironbark – Red Stringybark communities on rocky ridges.
Fire Regime	Aboriginal burning of grassy woodlands favoured grasses such as Themeda australis and native yam (Microseris lanceolata). An appropriate fire regime may be 3–15 years. Fire is rare due to fragmentation and lack of ground cover due to grazing. The prevalence of an exotic, annual ground flora has changed the fire regimes. Burning could decrease exotic annual species by flushing soil nitrogen.
Conservation Reserves	Flagstaff Memorial NR 6 (E2); Barton NR 6 (M); Minjary NP 30 (E3); Tumblong SCA 106 (E1); Oak Creek NR 100 (E3);
Total Area in Reserves (ha)	248
No. of Reps in Reserves	5
Explanation of Protected Areas	Flagstaff Memorial NR from Brickhill (1978a). Barton NR from White Box woodland in Lembit & Skelton (1998). VCA116 and VCA111 from DEC file notes. Tumblong SCA, Oak Creek NR and Minjary NR and from vegetation group 31 in Gellie & Fanning (2004). HE9901 and WT9902 from DNR database.
Secure Property Agreements	VCA116 Marra Cemetry VCA 4 (M); VCA111 Wallendbeen Cemetry VCA 3 (E1); HE9901 PA 6 (E2); WT9908 PA 64 (E2);
Total Area in Secure PAs	77
No. of Reps in Secure PAs	4
Total Area Protected (ha)	325
Area Protected Accuracy (%)	30
Protected Pre-Euro. Extent (%)	0.04
Protected Current Extent (%)	0.65
Total Reps in Protected Area	9
Common (>10000 ha in 1750)	5a: <1% in protected areas
Common Qualifiers	Inadequately across distribution
Key Sites for Protection	Some travelling stock routes, cemetries and roadsides contain good condition grassy White Box woodland. These include Guise's Hill TSR and Mangoplah Landcare site in Wagga Shire (Priday 2004), Warraderry Range in the Lachlan Catchment, Hovell's Creek and Bennet Springs TSRs in Boorowa Shire.

Threat Category	Critically Endangered
Threat/Protected Area Code	CE/5a
Threat Criteria	1; 4;
Planning and Management	Management advice is provided in the Grassy White Box Woodlands Information Kit (Lambert & Elix 2002). Prevent travelling stock routes from being sold off or overgrazed. Protect key sites in public conservation reserves. Off-reserve measures such as the Grassy Woodlands Conservation Management Network can protect sites in good condition on private land. Management of remnants may require regular burning or mowing to remove nutrients and annual species and stimulate reproduction of native forbs and grasses.
Listed Under Legislation	Listed TSCA (NSW Threatened Species Conservation Act); Nominated EPBCA (Com. Environmental Protection and Biodiversity Conservation Act);
Recovery Plan	Required
Photo1	ID266a_PC178-22.jpg
Photo Caption 1	ID266 *Eucalyptus albens* grassy woodland, Quamby-Thuddungra TSR south of Grenfell, (AGD66) 34°09'28" S 148°08'39" E, 12/10/02, J.Plaza;
Photo 2	ID266b_PC172-12.jpg
Photo Caption 2	ID266 *Eucalyptus albens – Themeda australis* grassy woodland, Canowindra Cemetery, (AGD66) 33°32'59" S 148°40'17" E, 10/10/02, J.Plaza;

Photo 3 ID266c_PC193-12.jpg

Photo Caption 3 ID266 *Eucalyptus albens* grassy woodland, Minjary National Park, (AGD66) 35°13'18" S 148°07'20" E, 16/10/02, J.Plaza;

Reference List 183; 166; 336; 316; 338; 276; 338; 343; 301; 179; 340; 348; 340; 356; 353; 372; 373;

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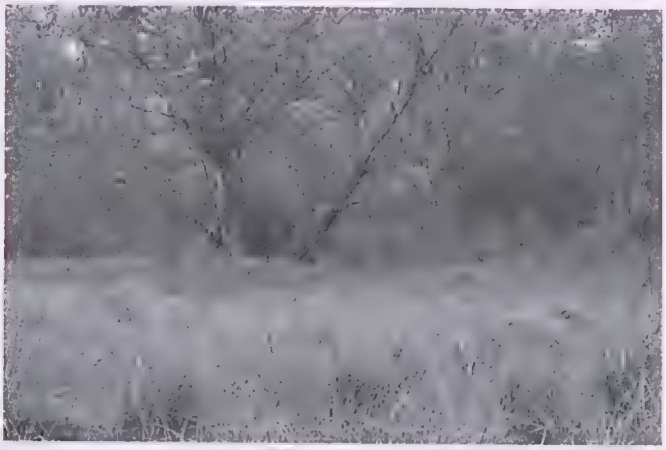
Appendix B. ID285. Full report of a swampy woodland that is restricted in its extent, mostly cleared and has an Endangered threat status.

Veg. Comm. ID No.	285
Common Name	**Broad-leaved Sally grass – sedge woodland on valley flats and swamps in the NSW South-western Slopes and adjoining South Eastern Highlands Bioregions**
Scientific Name	*Eucalyptus camphora subsp. humeana – Eucalyptus stellulata / Acacia melanoxylon – Acacia dealbata – Acacia kettlewelliae – Leptospermum continentale / Carex appressa – Poa labillardierei var. labillardierei – Juncus holoschoenus – Acaena novae-zelandiae*
Original Data Entry	J.S. Benson
Original Data Entry Date	1/02/2006
Formation Group	Eucalyptus Swamp Communities of the Eastern Coast and Tablelands
State Veg Map (Keith 2004)	Upper Riverina Dry Sclerophyll Forests;
State Landscapes (Mitchell 2002)	
NVIS Major Veg Sub-Groups	Eucalyptus low open woodlands with a grassy understorey;
Forest Type (RN 17)	143 – Swamp Gum/Black Gum/Broadleaved Sallee (P);
Characteristic Trees	*Eucalyptus camphora subsp. humeana; Eucalyptus stellulata; Eucalyptus robertsonii subsp. robertsonii; Eucalyptus bridgesiana*
Characteristic Shrubs/Vines/ Epiphytes	*Acacia dealbata; Acacia melanoxylon; Acacia kettlewelliae; Leptospermum continentale; Mirbelia oxylobioides; Hibbertia obtusifolia; Hovea linearis; Dicksonia antarctica; Cassinia aculeata; Epacris breviflora; Bossiaea foliosa*
Characteristic Groundcover	*Carex appressa; Poa labillardierei var. labillardierei; Juncus holoschoenus; Acaena novae-zelandiae; Senecio hispidulus var. dissectus; Microlaena stipoides var. stipoides; Geranium solanderi var. solanderi; Stellaria pungens; Phragmites australis; Themeda australis; Echinopogon ovatus; Hydrocotyle laxiflora; Ranunculus lappaceus; Geranium neglectum; Rubus parvifolius; Senecio minimus; Senecio diaschides; Calochlaena dubia; Blechnum nudum; Eleocharis sphacelata; Carex fascicularis; Juncus sarophorus; Dichondra repens; Persicaria decipiens; Gonocarpus tetragynus; Euchiton gymnocephalus; Mentha diemenica; Asperula conferta; Clematis aristata; Lomandra confertifolia subsp. rubiginosa; Lomandra longifolia; Lepidosperma laterale; Adiantum aethiopicum; Pteridium esculentum; Urtica incisa*
Characteristic Weed Species	*Rubus discolor; Hypericum perforatum; Aira elegantissima; Taraxacum officinale; Briza minor; Hypochaeris radicata; Holcus lanatus; Acetosella vulgaris; Rosa rubiginosa; Centaurium erythraea; Cirsium vulgare; Plantago lanceolata; Phalaris aquatica*
Weediness	Very high (>30%) with 10–30% cover
Threatened Plants	*Eucalyptus camphora subsp. humeana (restricted)*
Threatened Fauna	*Not assessed*
Mean Native Species Richness	40 +/- 10 spp in 20 X 20 m plot (Gellie & Fanning 2004)
Characteristic Qualifiers	(Quantitative Data)
Authority(s)	South West Slopes Swamp Gum Forest map unit in Gellie & Fanning (2004) and Vegetation Group 14 in EcoGIS (2005) for Upper Murray Valley reserves. Listed as a vegetation profile for Upper Tarcutta and Greenhills and Paddys river – Burra Valley land units in Stelling (1998). Noted as occurring in small patches south-east parts of Wagga Wagga Shire (Priday 2004). Grades into Tea Tree Shrubland riparian Broad-leaved Sally community ID302.
Authority Qualifiers	(Quantitative Data)
Interstate Equivalent(s)	Victoria: EEC 83: Swamp Riparian Woodland
Class. Confidence Level	High
Level of Classification	Association
Rainforest Structure (Webb)	Not applicable
Structure (WH)	Woodland;
Height Class (WH)	Mid-High;

Vegetation Description	Mid-high woodland dominated by Broad-leaved Sally (Eucalyptus camphora subsp. humeana) sometimes with Black Sally (Eucalyptus stellulata) grading into open forest dominated by Robertson's Peppermint (Eucalyptus robertsonii subsp. robertsonii), Blakely's Red Gum (Eucalyptus blakelyi) or Apple Box (Eucalyptus bridgesiana). The shrub layer is usually sparse and includes the tall shrubs Acacia dealbata, Acacia melanoxylon, Acacia kettlewelliae, Leptospermum continentale and the low shrubs Mirbelia oxylobioides, Hibbertia obtusifolia, Hovea linearis, Cassinia aculeata, Epacris breviflora and rarely Bossiaea foliosa. The tall tree fern Dicksonia antarctica occurs in some narrow creeks and Bracken Fern (Pteridium esculentum) may occur. The ground cover is usually dense being dominated by grasses such as Poa labillardierei var. labillardierei, Microlaena stipoides var. stipoides and Echinopogon ovatus. The sedges Carex appressa is most often present and in some wetter sites Eleocharis sphacelata and Carex fascicularis occur, along with the Common Reed (Phragmites australis). Rushes, including Juncus holoshchoenus and Juncus sarophorus, also occur at wet sites. Forbs include Senecio hispidulus var. dissectus, Hydrocotyle laxiflora, Ranunculus lappaceus, Geranium neglectum and Acaena novae-zelandie. Occurs on alluvial or colluvial organic grey to brown podsolic clay loam soils, on poorly drained valley flats, surrounding swamps or lining creeks in hill or mountain landscapes generally above 600 m altitude in the southern section of the NSW South Western Slopes and adjoining South Eastern Highlands Bioregions. The underlying lithology is mainly granite or granodorite. This community is substantially cleared on private land but small patches ocurr in state forests and conservation reserves such as at Tin Mines Camping Area in Woomargama National Park. This community is restricted in extent and most areas on private land and some on public land are infested with weeds, particuarly Blackberry (Rubus discolor). Another riparian shrubland community (ID302) in this region contains Broad-leaved Sally as an emergent tree.
Mapped/Modelled	Current extent partly mapped
Mapping Info	Mapped and sampled in some reserves. Relatively easy to map from aerial photographs due to its canopy signature and occurrence along creeks or on flats but only small patches occur and these are best mapped at scales > 1:25000.
Adequacy Of Plot Sampling	Inadequate
Climate Zone	Montane: no dry season (mild summer); Temperate: no dry season (warm summer);
IBRA Bioregion (v6)	NSW South-western Slopes (30–70%); South Eastern Highlands (30–70%);
IBRA Sub-Region	Bondo (30–70%); Upper Slopes (30–70%);
Botanical Division	South Western Slopes (SWS) (>70%);
Local Govt. Areas	Greater Hume (1–30%); Tumbarumba (1–30%); Tumut (1–30%);
CMAs	Murray (>70%); Murrumbidgee (1–30%);
MD Basin	Yes
Substrate Mass	Alluvium; Igneous rocks;
Lithology	Alluvial loams and clays; Granite;
Great Soil Group	Gleyed podzolic soil; Humic gley; Peaty podzol;
Soil Texture	Clay loam;
Landform Patterns	Hills; Mountains;
Landform Elements	Swamp; Terrace flat; Valley flat;
Land Use	Grazing; Nature Conservation;
Impacts of Euro. Settlement	Major alteration of species composition;
Pre-European Extent (ha)	8000
Pre-European Accuracy (%)	30
Pre-European Qualifiers	Estimated from extant vegetation maps: part range
Pre-European Comments	Priginally would have been present on the edges of low lying poorly drained swamps, along drainage lines and on some river flats in the Upper Slopes Sub-region of the NSW SW Slopes and western side of South East Highlands Bioregion from just north of Tumut to Victoria.
Current Extent (ha)	2000
Current Extent Accuracy (%)	30
Current Extent Qualifiers	Estimated from mapped extant vegetation: part range
Current Extent Information	Remnants occur along drainage lines and on the edges of swamps in the Tumut to Tumbarumba region but many areas have been cleared for agriculture or pine plantations. Some small stands occur in reserves.
Percent Remaining	25

Percent Remaining Accuracy (%)	±50
Degree of Fragmentation	Naturally fragmented stands of variable patch sizes with <50% extent remaining
Recoverability	Moderate health as structure and/or composition altered. Likely to recover considerably if causal factors and secondary impacts removed.
Threatening Processes	Considered to tbe a threatened community because of its limited extent mainly on private land, weed invasion – particularly by Blackberry (Rubus discolor) and hydrological changes along rivers and creeks. Many areas have been cleared and clearing for pine plantations continues as of 2007.
Threat Process List	Clearing for agriculture; Herbicides, pesticides or other chemical pollution; Hydrology: disruption of natural flooding regimes; Nutrient changes through fertilizers or runoff; Weed (exotic) invasion;
Variation and Natural Disturbance	Species composition varies with altitude and degree of water-logging. Some areas are sedge-dominated, others contain more shrubs and grasses.
Adjoining Communities	Grades into open forests dominated by Eucalpytus robertsonii (ID295) and woodlands dominated by Apple Box (Eucalyptus bridgesiana) (ID283) or Blakely's Red Gum (Eucalyptus blakelyi). Broad-leaved Sally also occurs in ID302 that is dominated by woody Myrtaceous shrub species along major rivers.
Fire Regime	Occasionally burnt by wildfire. Perhaps a 30–60 year variable fire frequency. Some areas on private land may be burnt more often by landholders.
Conservation Reserves	Bogandyera NR 6 (M); Murraguldrie FR 10 (E3); Woomargama NP 113 (M); Woomargama SCA 6 (E1);
Total Area in Reserves (ha)	135
No. of Reps in Reserves	4
Explanation of Protected Areas	Woomargama NP and SCA areas from Vegetation Group 20 in Gellie & Fanning (2004). Murrugulderie Flora Reserve estimate from text in Priday (2002). Mapped in Boganderya NR on the western side of Mount Ikes by EcoGIS (2005). A similar community is present in north-western Kosciuszko National Park.
Secure Property Agreements	
Total Area in Secure PAs	0
No. of Reps in Secure PAs	0
Total Area Protected (ha)	135
Area Protected Accuracy (%)	50
Protected Pre-Euro. Extent (%)	1.68
Protected Current Extent (%)	6.75
Total Reps in Protected Area	4
Restricted (>1000<10000 ha in 1750)	5b: <5% in protected areas
Restricted Qualifiers	Inadequately across distribution
Key Sites for Protection	Some sites on private land may be worth protection through conservation agreements. Good stands surround Tarcutta Swamp near Courabyra and on public land on Mount Garland Track 5 km south of Tumbarumba. Areas occur along Paddy's River south-east of Tumbarumba and along other creeks in the Tumbarumba region.
Threat Category	Endangered
Threat/Protected Area Code	E/5b
Threat Criteria	4; 2;
Planning and Management	Avoid clearing, over-grazing and draining flats that support this community. Fence off and maintain riparian vegetation. Avoid grading roads and soil disturbance in this community. Controlling weeds, including Blackberry, is an imperative for enhancing the condition of this community.
Listed Under Legislation	
Recovery Plan	Required
Photo1	ID285a_DX28027.jpg

Photo Caption 1	ID285 Broad-leaved Sallee (*Eucalyptus camphora* subsp. *humeana*) bordering Tarcutta Swamp near Batlow, NSW South East Highlands Bioregion (AGD66) 35° 40.470' S 148° 02.096' E, 1/5/2006, J. Plaza;
Photo 2	ID285b_DX28285.jpg 
Photo Caption 2	ID285 Broad-leaved Sallee *(Eucalyptus camphora* subsp. *humeana*) with a sedgeland wetland at Tin Mines Camping Area Woomargama National Park east of Albury NSW south western slopes, (AGD66) 35° 51.665' S 147° 28 503' E, 3/5/2006, J. Plaza;
Photo 3	ID285c_DX28231.jpg
Photo Caption 3	ID285 Broad-leaved Sallee (*Eucalyptus camphora* subsp. *humeana*) with the tall sedge *Carex fasicularis* lining a narrow creek in Woomargama National Park east of Albury NSW, (AGD66) 35° 52.683' S 147° 19 820' E, 2/5/2006, J. Plaza;
Reference List	340; 341; 316; 350;
References	Gellie, N. & Fanning, M. (2004) Final report of vegetation ecosystems in new and existing conservation reserves, south west slopes region 2002–2004, version 3. Report to NSW Department of Environment and Conservation: Queanbeyan; Stelling, F. (Ed.) (1998) South West Slopes Revegetation Guide (Murray Catchement Management Committee and Department of Land & Water Conservation: Albury); Priday, S. (2004) The native vegetation and threatened species of the City of Wagga Wagga. Unpublished report. (NSW National Parks and Wildlife Service, Southern Region: Queanbeyan); EcoGIS (2005) Vegetation of the Upper Murray reserves: Report to NSW Department of Environment and Conservation (DEC Upper Murray Area, Snowy Mountains Region: Khancoban);

Appendix C. ID186: Short report (28 fields) of a broadly classified, widely distributed, shrubby low woodland on rocky hillcrests that is well represented in the protected area system and has a Least Concern threat status.

Veg. ID No	186		
Common Name	**Dwyer's Mallee – Black Cypress Pine – Currawang shrubby low woodland on rocky hills mainly in the NSW South-western Slopes Bioregion**		
Scientific Name	*Eucalyptus dwyeri – Callitris endlicheri – Acacia doratoxylon / Calytrix tetragona – Dodonaea viscosa subsp. spatulata – Grevillea floribunda – Brachyloma daphnoides subsp. daphnoides / Gonocarpus elatus – Lepidosperma laterale – Chrysocephalum semipapposum – Austrostipa densiflora*		
Characteristic Trees	*Eucalyptus dwyeri; Callitris endlicheri; Acacia doratoxylon; Eucalyptus dealbata; Eucalyptus sideroxylon; Allocasuarina verticillata; Eucalyptus goniocalyx; Eucalyptus macrorhyncha*		
Characteristic Shrubs/Vines/ Epiphytes	*Calytrix tetragona; Dodonaea viscosa subsp. spatulata; Grevillea floribunda; Brachyloma daphnoides subsp. daphnoides; Cassinia laevis; Acacia linearifolia; Acacia verniciflua; Platysace lanceolata; Dodonaea viscosa subsp. mucronata; Hibbertia obtusifolia; Acacia paradoxa; Acacia deanei subsp. deanei; Acacia buxifolia subsp. buxifolia; Exocarpos cupressiformis; Micromyrtus ciliata; Phebalium obcordatum; Melichrus urceolatus; Persoonia curvifolia; Kunzea ambigua; Senecio garlandii; Leptospermum divaricatum; Phylotheca difformis subsp. difformis; Philotheca salsolifolia subsp. salsolifolia; Phyllanthus hirtellus; Allocasuarina diminuta subsp. diminuta; Acacia lineata; Santalum acuminatum; Leptospermum multicaule; Lissanthe strigosa subsp. strigosa; Acacia verniciflua; Correa reflexa var. reflexa; Pomaderris prunifolia var. prunifolia; Pultenaea procumbens*		
Characteristic Groundcover	*Gonocarpus elatus; Lepidosperma laterale; Chrysocephalum semipapposum; Austrostipa densiflora; Austrodanthonia eriantha, Austrodanthonia pilosa; Austrodanthonia caespitosa; Austrostipa scabra subsp. scabra; Aristida ramosa, Stypandra glauca; Cheilanthes distans; Cheilanthes sieberi subsp. sieberi; Cheilanthes austrotenuifolia; Austrostipa mollis; Goodenia ovata; Dampiera lanceolata subsp. lanceolata; Amphipogon caricinus var. caricinus; Calotis cuneifolia; Poa sieberiana var. sieberiana; Themeda australis; Thyridolepis mitchelliana; Hybanthus monopetalus; Astroloma humifusum; Stuartina muelleri; Aristida jerichoensis var. jerichoensis; Lomandra filiformis subsp. coriacea; Arthropodium minus; Einadia nutans subsp. nutans; Xerochrysum viscosa; Goodenia hederacea subsp. hederacea; Laxmannia gracilis; Wahlenbergia stricta subsp. stricta; Gonocarpus tetragynus*		
Structure	Open Mallee Woodland; Open Mallee Shrubland; Woodland; Mallee Woodland;		
Vegetation Description	Woodland or mallee shrubland dominated by Dwyer's Red Gum (Eucalyptus dwyeri), Black Cypress Pine (Callitris endlicheri) with Currawang (Acacia doratoxylon) often present. Drooping She-oak (Allocasuarina verticillata) may be present in areas infrequently burnt. Mugga Ironbark (Eucalyptus sideroxylon) may be present on mid-lower hill-slopes. Tumbledown Gum (Eucalyptus dealbata) may occur in eastern occurrences. The understorey contains a mid-dense to sparse shrub layer that includes Calytrix tetragona, Cassinia laevis, Grevillea floribunda, Acacia linearifolia, Dodonaea viscosa subsp. spatulata, Dodonaea viscosa subsp. mucronata, Acacia paradoxa, Correa reflexa, Acacia lineata and in some eastern locations patches of Kunzea ambigua. The ground cover is sparse and can be very sparse on rocky areas and rocks may compose 60% of a site. Small shrubs such as Melichrus urceolatus, Astroloma humifusum, Platysace lanceolata, Brachyloma daphnoides and Hibbertia obtusifolia may be present along with grasses such as Austrodanthonia spp., Austrostipa densiflora, Austrostipa scabra, Austrostipa mollis, Aristida ramosa and Themeda australis. The sedge Lepidosperma laterale is often abundant. Forbs include Gonocarpus elatus, Calotis cuneifolia, Stuartina muelleri and Chrysocephalum semipapposum. Rock Ferns (Cheilanthes spp.) are usually common. The rare plant Senecio garlandii occurs at several sites including The Rock Nature Reserve south of Wagga Wagga. The ground cover may form rock forblands in some areas and on a different scale this could be described as a community in itself. Occurs on skeletal or shallow lithosol soils derived from sandstones, granites or other siliceous substrates including quartzite and psammite. Generally present on steep upper hill-slopes, ridgelines or steep gullies on rocky hills mainly in the NSW South-western Slopes Bioregion but extending into the south-eastern edge of the Cobar Peneplain Bioregion. Due to its location on rocky ridges most of this community remains uncleared but grazing by stock or feral animals may threaten some locations. A broadly classified community that could be divided with floristic analyses.		
IBRA Bioregion (v6)	Cobar Peneplain (1–30%); NSW South-western Slopes (>70%);		
CMAs	Lachlan (30–70%); Murray (1–30%); Murrumbidgee (30–70%);		
Pre-European Extent (ha)	60000	***Pre-European Accuracy (%)***	50
Current Extent (ha)	50000	***Current Extent Accuracy (%)***	50
Percent Remaining (%)	83	***Percent Remaining Accuracy (%)***	80

Conservation Reserves	Blue Mallee FR 10 (E3); Cocoparra NP 6030 (E1); Cocoparra NR 3200 (E1); Eugowra NR 100 (M); Goobang NP 500 (E1); Ingalba NR 400 (E2); The Charcoal Tank NR 2 (E1); The Rock NR 193 (E2); Weddin Mountains NP 5145 (E1); Livingstone NP 300 (E2); Livingstone SCA 17 (E1); Boginderra Hills NR 320 (E2); Benambra NP 30 (E2); Tabletop NR 23 (E3); Koorawatha NR 420 (E1); Dananbilla NR 1000 (E1); Woomargama NP 200 (E3); Ulandra NR 2400 (E2); Buddigower NR 40 (E2);		
Total Area in Reserves (ha)	20330		
Secure Property Agreements	CO9801 PA 525 (M); VCA044 VCA 12 (E3); WE9904 PA 45 (E3);		
Total Area in Sec. PAs	582		
Total Area Protected (ha)	20912	***Total Area Protected Accuracy (%)***	30
Threat Category	Least Concern	***Threat Criteria***	1; 4;
Threat/Protected Area Code	LC/1a		
Photo	ID186a_PC185-20.jpg 		
Photo Caption	ID186 *Eucalyptus dwyeri – Acacia doratoxylon – Callitris endlicheri* low woodland, Ulandra Nature Reserve, (AGD66) 34°46'30" S 147°53'54" E, 14/10/02, J.Plaza;		
Reference List	183; 177; 263; 152; 24; 154; 153; 69; 180; 34; 46; 143; 316; 340; 179; 372; 373; 150; 379;		

Appendix D. ID335: Short report of a valley tussock grass – sedge wetland that is restricted in extent and Endangered.

Veg. Comm.ID No	335		
Common Name	**Tussock grass – sedge – rush – reed valley flat wetlands on organic clay loams in the Upper Slopes Sub-region of the NSW South-western Slopes Bioregion**		
Scientific Name	*Phragmites australis – Typha domingensis / Poa labillardierei var. labillardierei – Carex appressa – Juncus homalocaulis – Rumex brownii*		
Characteristic Trees	*Eucalyptus blakelyi; Eucalyptus melliodora*		
Characteristic Shrubs/Vines/ Epiphytes	*Phragmites australis; Typha domingensis; Acacia dealbata; Babingtonia densifolia;*		
Characteristic Groundcover	*Poa labillardierei var. labillardierei; Carex appressa; Juncus homalocaulis; Rumex brownii; Juncus fockei; Juncus holoschoenus; Acaena ovina; Cynodon dactylon; Microlaena stipoides var. stipoides; Aristida ramosa var. ramosa; Geranium neglectum; Geranium retrorsum; Dichopogon fimbriatus; Caesia parviflora var. parviflora; Xerochrysum viscosa; Arthropodium milleflorum; Microtis unifolia*		
Structure	Sedgeland; Open Sedgeland		
Vegetation Description	Tall tussock grassland to mid-high sedgeland to rushland or reedland dominated by tussock snow grass Poa labillardierei var. labillardierei, sedges including Carex appressa, rushes such as Juncus homalocaulis and Juncus fockei. In wetter areas a taller layer of waterplants including the Common Reed (Phragmites australis) and bulrush (Typha domingensis) may be present. Other grass species include Microlaena stipoides var. stipoides and Cynodon dactylon. Forbs species include Rumex brownii, Acaena ovina, Geranium neglectum, Geranium retrorsum, Dichopogon fimbriatus, Caesia parviflora var. parviflora, Xerochrysum viscosa and Arthropodium milleflorum. Shrubs are sparse but Acacia dealbata or Acacia mearnsii species may be present along with Babbingtonia densiflora and Leptospermum spp.. The trees Blakely's Red Gum (Eucalyptus blakelyi) or Yellow Box (Eucalyptus melliodora) may border the swamp or overhang small swamps that line narrow creeks. Degraded areas of this community are often dominated by exotic weed species such as Sharp Rush (Juncus acutus), Willow (Salix spp.) and Phalaris spp. These weed-infested areas are common in the Boorowa – Young districts often on saline soils. It is difficult to discern the original composition of these valley flat wetlands but they may have been wetter and dominated by reeds and rushes. Occurs on silty or peaty clay loam with high levels of organic material on alluviums derived from a range of substrates along watercourse where sediment has accumulated to form valley flats or where springs may feed valley soaks in the Upper Slopes Sub-region of the NSW SW Slopes Bioregion and adjoining parts of the South Eastern Highlands Bioregion. Grades into ID79 River Red Gum woodland along watercourses to the west and into Blakely's Red Gum and box woodland upslope from the watercourses. Some floristic affiliation to to bogs at higher altitude on the tablelands. Most of the sites dominated by Carex appressa are highly degraded due to heavy stock grazing and now contain a limited species composition. Very few sites are in near-natural condition. As of 2007, this community requires more sampling to improve its definition and description. Due to threats and loss of extent is is an endangered plant community.		
IBRA Bioregion (v6)	NSW South-western Slopes (30–70%); South Eastern Highlands (1–30%);		
CMAs	Lachlan (1–30%); Central West (1–30%); Murrumbidgee (1–30%); Murray (1–30%);		
Pre-European Extent (ha)	6000	Pre-European Accuracy (%)	50
Current Extent (ha)	1000	Current Extent Accuracy (%)	30
Percent Remaining (%)	17	Percent Remaining Accuracy (%)	±50
Conservation Reserves			
Total Area in Reserves (ha)	0		
Secure Property Agreements			
Total Area in Sec. PAs	0		
Total Area Protected (ha)	0	***Total Area Protected Accuracy (%)***	
Threat Category	Endangered	***Threat Criteria***	4; 5; 1;
Threat/Protected Area Code	E/5b		

Photo	ID335a_SWS0507160.jpg

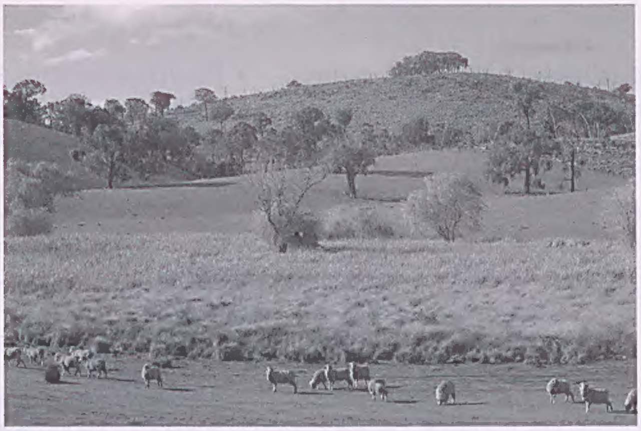


Photo Caption	ID335 *Poa labillardierei – Phragmites australis – Typha – Juncus* swamp on alluvial organic soil in a valley near Walla Walla east of Rye Park in the upper Lachlan River catchment, (AGD66) 34 32 833 S 148 57.007 E, 29/5/2007, Jaime Plaza;
Reference List	353; 308; 353;

Information for authors

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Version 2 of the NSWVCA database.
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